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PROCEEDINGS OF THE NATIONAL CONFERENCE ON AIR POLLUTION HELD IN WASHINGTON, D. C. ON NOVEMBER 18-20, 1958

Public Health Service
Washington, D. C.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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Proceedings • National Conference on AIR POLLUTION

Washington, D.C. *November 18–20, 1958*

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

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FOREWORD

The unprecedented growth of our cities and industries in recent years lends new urgency to the consideration of health problems related to the urban environment. Pollution of the air is one of these complex and potentially serious problems of modern living.

It was felt that an opportunity should be provided for persons representing a wide variety of interests and disciplines, directly or indirectly related to air pollution control, to discuss the current status of knowledge in the field and chart a practicable future course of action.

The response to this conference call was most gratifying. A wealth of material, much of it reported for the first time, was presented and discussed during the three-day sessions. Recommendations were made which reflect the diversity of interest represented at the Conference and which should point the way to action by governmental agencies at all levels, by industries, and by private institutions and organizations.

It is hoped that this volume will constitute a valuable reference work for persons interested in any aspect of the many-faceted air pollution problem, and that the 1958 National Conference on Air Pollution will have been a significant event in the Nation's efforts to provide and preserve a safe and healthful environment.

Dr. Leroy E. Burney
Surgeon General
Public Health Service

PREFACE

In planning and carrying out the 1958 National Conference on Air Pollution, the Public Health Service received invaluable assistance from several groups of advisors, to whom the success of the Conference is due in large measure.

It is a pleasure to acknowledge our debt, in particular, to the members of the Steering Committee and Inquiries Committee for their indispensable contribution to the Conference planning, and to the chairmen and vice-chairmen of the discussion groups for their tireless efforts both before and during the Conference itself.

This volume of *Proceedings* is based on the formal presentations made to the plenary and group sessions, plus a stenographic transcript of the discussion group meetings. It has been edited only to the extent that repetitions and formalities have been eliminated. We believe that it contains all the essential material, including the discussion of controversial issues upon which no consensus was reached.

It is a pleasure to make this report available to all those who are interested in the quality of the Nation's air.

Malcolm C. Hope
Executive Secretary
National Conference on Air Pollution

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First Day

PLENARY SESSIONS

The first plenary session of the National Conference on Air Pollution, sponsored by the Public Health Service, U.S. Department of Health, Education, and Welfare, convened at 9:30 a.m. in the Sheraton-Park Hotel, Washington, D.C.

Morning Session—Tuesday, November 18

Chairman
Dr. Leroy E. Burney
Surgeon General, Public Health Service

MESSAGE FROM THE
PRESIDENT OF THE UNITED STATES

Please give my greetings to the delegates attending the National Conference on Air Pollution.

To maintain our industrial and scientific progress without impairing the purity of the air we breathe is of primary concern to the Nation. Government, industry, and individual citizens have mutual responsibility in this vital area. I am sure the goals and guidelines coming out of this discussion will help us to fulfill them.

It is a pleasure to send my best wishes for a successful conference and a pleasant stay in the capital city.

Dwight D. Eisenhower

Status Report to the Nation

Dr. Leroy E. Burney
Surgeon General, Public Health Service
U.S. Department of Health, Education, and Welfare

I welcome you to this National Conference on Air Pollution. I also want to thank each of you personally for giving 3 days of your busy life to a discussion of the air-pollution problem. I believe sincerely that the urgent need for such a discussion justifies this imposition. We are witnessing a dynamic transition in our environment. The new world we are creating—with higher standards of living, more comfortable, safer from communicable disease—brings with it new problems which will not wait for leisurely solution. They demand immediate readiness on the part of persons representing a great variety of disciplines and skills, a readiness based on mutual knowledge and mutual confidence.

Air pollution is one of these problems. For this reason, we have brought you together. If our sponsorship of this conference enables all of you to learn from each other—if in this sense we can act as a catalyst—we shall feel that our efforts have been successful.

In the presence of so many chemists I should add that we do not intend to fulfill the complete definition of a catalyst, as an agent which accelerates a reaction while remaining unchanged. We expect to enter fully into the reaction and to be improved by our participation.

My assignment this morning is listed in the program "Status Report to the Nation." Actually, the findings of the conference as a whole will constitute a status report, consolidating information on existing status and sharpening the perspective for the future.

Therefore, my talk will be designed to take its place as one portion of this total status report. I shall report on the current status of the Public Health Service program in air pollution, after approximately 3 years of operation under Public Law 159 of the 84th Congress—what we have done and what we have learned. We expect you to tell us what the logical course of action seems to be in the future. This does not mean that we have no ideas of our own, but that we want a synthesis of opinion on the role of each of us in this growing problem of contemporary life.

Public Law 159, enacted by Congress and signed by President Eisenhower in 1955, is in itself a manifestation of what I consider to be the most significant single fact in the air pollution picture—the rising tide of public interest in the quality of our Nation's air. The attendance of many of you here today is another evidence of this concern. Until a few years ago, air pollution was almost exclusively of interest to the professionals in the field.

As of today, the problem has emerged into public consciousness from coast to coast. This has been sparked by the development of acute situations and the growing realization of the increasing potential for air pollution in our cities. The recent action by the Governors' Conference in calling for a report on various types of State legislation available for adoption, and the recently expressed interest of the Conference of Mayors, indicate that our highest officials at the State and local levels are feeling this increase in public awareness. In the past 2 years, 11 different States have passed initial laws or strengthened existing air pollution legislation.

Unmistakably, the informed people in our Nation are no longer taking for granted the air we breathe. They are rejecting the old maxim that a prosperous city is necessarily a dirty city. However, in only a few places has this attitude been accepted by the public to the extent that it has demanded preventive action. The public as a whole still needs to ask several searching questions about air pollution. What is it doing to us? What is it costing us? Just how inevitable is it?

Above all, the people should ask what it is doing to their health. President Eisenhower, in his special health message to Congress in January, 1955, struck the keynote when he said: "As a result of industrial growth and urban development, the atmosphere over some population centers may be approaching the limit of its ability to absorb air pollutants *with safety to health.*"

We need not look for nationwide epidemics from air pollution. We *have* been alerted by severe outbreaks, both within industrial establishments and in communitywide smogs under certain atmospheric conditions. And now, after several years of closer observation, investigators are finding a definite association between community air pollution and high mortality rates due to cancer of the respiratory tract, including the lungs, cancer of the stomach and esophagus, and arteriosclerotic heart disease.

In addition to these more serious problems of personal health, we are confronted now with many troublesome manifestations of air pollution—acute nuisances, plant damage, reduced visibility, odors, and economic blight.

The law directs the Public Health Service to conduct and support research and to provide technical services to State and local governments and to private agencies. All of our activities in the air-pollution field can be classified under these two headings of research and technical services.

In an area so vast, complex, and relatively unexplored as air pollution, the greatest need has been to learn. Consequently we have devoted a great majority of our resources—about 80 percent of the $12.5 million thus far appropriated—to research. The remaining 20 percent of our budget supports activities classified as technical assistance, including consultation services, assignment of personnel on request to help with specific problems, demonstration and training projects, and others.

It would not be possible for me to describe in detail this morning the many research projects presently under way with Federal and other support. A number of the papers which you will hear and discuss in your group sessions tomorrow are based on federally-sponsored research, a fact which gives me great satisfaction and pride. I shall attempt only to indicate the broad general lines along which investigation is proceeding.

The goal of research on the health effects of atmospheric pollution can be simply stated: to determine the conditions under which toxic substances in the community atmosphere affect human health adversely, and the measures which must be applied to prevent adverse effects.

But with this statement of purpose, simplicity stops. The investigator is confronted by a seemingly infinite variety of polluting materials, reacting in the giant test tubes of air above our cities. Also, he is searching for effects, not in relation to one disease with one specific cause but rather in relation to a large number of diseases, of multiple etiology, many of which are not in themselves clearly understood.

Medical research in this field includes both epidemiologic and laboratory studies. Comparing mortality and morbidity data with various indices of air pollution, we are finding interesting parallels—cities with the heaviest pollution loads tend to rank high in death rates for a number of diseases.

The relationship of cancer to atmospheric pollution, for example, is being explored. We know that cancer-producing agents are in the air we breathe. Cancers can be produced in animals using concentrates of urban smog. We know that lung cancer death rates in the largest cities are twice as high as those in nonurban areas. The case has not yet been proved, but the weight of circumstantial evidence grows heavier as research progresses.

A follow-up study on the population of Donora, Pa., where a week of smog in 1948 caused 20 deaths and widespread illness, shows that the people who were made ill by the smog, in general, have had poorer health and higher mortality rates these past 10 years than their neighbors who were unaffected by the episode—this, even though air pollution in Donora has been substantially reduced.

Laboratory experiments are yielding significant information on a number of specific pollutants which occur in community air. One of these, ozone, causes scarring of the lungs in animals which breathe it in sublethal doses over a period of months. Other experiments indicate that ozone may have an effect on enzyme systems as well as on the respiratory tract and that aerosols aggravate the harmful effects of sulfur dioxide. It has been proved also that sulfur oxides, in concentrations sometimes found in community air, make breathing more difficult for human beings.

The National Air Sampling Network is now approaching a coverage worthy of its name. This plan for systematic measurement of air pollution depends upon the voluntary action of States and cities. Since January 1, 1957, the cooperating agencies have been using uniform sampling methods. At present, 180 cities and 51 nonurban areas have sampling stations, all manned by State and local personnel. Every State and Territory has at least one urban and one nonurban sampling site. The Public Health Service has provided the equipment, established the procedures, and is analyzing the samples. It is important to note that seven States have established their own sampling networks, thus giving more intensive coverage than the National Network is equipped to do.

Thus far the National Network measures and analyzes only particulate matter—solid particles and liquid droplets in the air. The need to include measurements of gaseous pollution is recognized, and will be met as technical and economic problems are overcome.

We recognize that a country as large as ours requires much larger resources than are available at the present time to sample and analyze air pollution on an adequate scale. The National Air Sampling Network is a good foundation for future expansion and refinement.

The Sanitary Engineering Center at Cincinnati is conducting many other studies in the engineering and physical sciences. They deal with measurement of pollutants at the source, behavior and dispersal of pollutants in the atmosphere, their various effects on vegetation and structural materials, and methods of control. The role of the automobile engine as a source of air pollution is under study. Some of our most valuable work is being done in improvement of equipment for continuous monitoring and in refinement of analytical methods.

The Public Health Service is collaborating with other Federal and non-Federal agencies in research areas. For example, the U.S. Weather Bureau is clarifying the conditions of dispersal of pollutants, and has improved the accuracy of prediction of air pollution buildups. The U.S. Bureau of Mines has developed and applied methods of analyzing automobile exhausts.

A project now under way in Nashville, Tenn., combines medical and engineering studies in a manner which may establish a pattern for future investigations. We are studying air-pollution levels in various parts of the city by intensive sampling, and at the same time conducting an epidemiologic study based on place and duration of residence within the city. Among the health data recorded are cause and frequency of mortality, incidence of various diseases, and presence of carbonaceous dust in the lungs. Thus we are attempting to pinpoint pollution's effect on people's health where they live.

Control of air pollution demands not only additional knowledge through research but also more adequate resources, both in personnel and in materiel, at State and local levels. The Public Health Service has initiated action to help fulfill these needs. We receive many requests for technical assistance, ranging from limited consultation to large-scale participation in projects such as State and municipal air-pollution surveys. We meet these requests to the extent of our capabilities, and supplement direct assistance by means of grants for demonstration projects.

Training courses are offered by the Sanitary Engineering Center, both in Cincinnati and in the field. More than 900 persons took part in these courses during fiscal year 1958, and the total for 1959 should be considerably higher. Interestingly, personnel from industry make up a higher percentage of the enrollees each year. It is encouraging that at least 14 universities are now offering graduate courses for advanced degrees in subjects related to air pollution, most of these having been established with Public Health Service grants.

Before closing, I should like to return to the broader problems of environment and health, of which air pollution and its control make up one part. A few minutes ago, referring to the circumstantial evidence relating cancer to atmospheric pollution, I remarked that the case has not yet been proved. This legal metaphor is frequently used. I submit to you that it is misleading.

In law, the suspect is innocent until his guilt has been proved beyond reasonable doubt. In the protection of human health, such absolute proof often comes late. To wait for it is to invite disaster, or at least to suffer unnecessarily through long periods of time.

Many years ago, before anyone had seen a germ or positively identified a single causative agent of epidemic diseases, farsighted leaders observed the association between epidemics and filth. Wherever they had sufficient foresight to act on this circumstantial evidence, they made striking progress. Cleaning up the city filth resulted in better health. Years later they found out why.

I suggest that our present position in respect to contemporary health problems, especially those relating to the urban environment, may be parallel to that of Pasteur's predecessors.

The city is the great sociological fact of midcentury American life. All of us have seen the population statistics. All of us have read the predictions calling for gigantic supercities in the immediate future: a solid urban complex from Boston to Washington and perhaps from Portland to Norfolk on the Atlantic seaboard; a similar unbroken mass from San Diego to San Francisco on the Pacific; a third megalopolis along the southern shores of the Great Lakes.

Another index of our growth is the increase in our national output. The gross national product is doubling every 17 years, an almost unbelievable acceleration spurred by an $8 billion annual investment in research. And the more we produce, the more problems we create in terms of wastes to be disposed of safely.

Finally, and perhaps most significantly of all, our new world differs from the old not only in degree but also in kind. Today we are dealing with processes and products which were unheard of prior to World War II. In 10 more years, still more new substances will have been added to our environment. I need only refer to a few examples—the petrochemicals and other synthetics, the soaring future of nuclear technology and high energy fuels.

This, then, is the new environment we are creating. Are we ready, as professionals and administrators, to solve the problems it produces?

"The wind bloweth whither it listeth." Air—and therefore polluted air—respects no boundary lines, geographic, political, professional, or disciplinary. In our common struggle against air pollution, are we as flexible as the enemy? Here and there, yes.

Cities are banding together to form countywide air-pollution control districts. Counties are merging their resources where it is evident that they can be more effective by doing so, as in the San Francisco Bay area. The Interstate Sanitation Commission covering the metropolitan area of New York City demonstrates that State governments can plan and act together. Work between Americans and Canadians in the Detroit-Windsor area is a fine, but little-known, example of international cooperation in the interest of human health and well-being.

Can we in the United States be equally flexible in regard to the less tangible but sometimes more stubborn boundary lines that separate profession from profession, special interest from special interest? I believe that we can.

The problems that come as byproducts of our almost unbelievable material progress demand everybody's skills and knowledge. More than that, they demand genuine cooperation. We can no longer ask "Who's going to be in charge?" or "Who's going to get the credit?" We must ask "How can we most effectively work together?" Nor can we ask "Can we afford to clean up the air?" We cannot afford not to. It costs cities more to endure dirty air than to apply the controls we now have. Controlling air pollution will cost big money, but it is an essential investment.

Assuredly we all have the same goal—a safe and healthful environment in which everyone may enjoy the fruits of progress.

Your presence here today, as representatives of so wide a variety of interests and competencies, is a heart-warming assurance to me that we can—we will—meet the challenge of air pollution.

State and Community Needs and Responsibilities

Dr. Herman E. Hilleboe

Commissioner, New York State Department of Health, Albany

Representing the Association of State and Territorial Health Officers

In 1948—just 3 years after World War II—our Nation's auto makers had succeeded in putting 40,600,000[1] vehicles on America's highways and main streets. They were just getting started. Last year there were 66,400,000 vehicles and we are just now getting around to asking ourselves: where in heaven's name are we going to park them all?

But let's save that question for some future National Conference on Parking Problems. Right now, we are concerned with air pollution and I mentioned those figures on automobiles only to dramatize the fantastic pace at which our Nation's industrial expansion is traveling. I do this so we may gain some grasp of the volume of air pollution that hangs so heavily over the industrial and urban parts of our Nation. Only a part of this pollution comes from motor vehicles. I need hardly review for you the monumental price in human health and welfare that this burnt offering to the gods of progress exacts. Most of you are familiar with the past, so let us focus our attention on the present and the future.

One thing that I will not attempt to do is to tell you what resources every community needs to control its air pollution. This is a question that must be determined by the extent of each community's problem and how each community determines the question of "need." Even if I were able to detail for you the number of men, the types of equipment, and the methods of enforcement that would be needed to solve the air-pollution problems of a city like, say, Newark, N.J., I would have accomplished nothing. For that same plan would most likely be nothing more than a lot of arrant nonsense for a city like

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[1] National Safety Council figures.

Detroit, Mich. So I will avoid discussing any so-called "model plan" for a State or community and admit that air-pollution control requires precise tailoring for each area concerned.

Let's also avoid any preliminary discussion about whether or not air pollution is a problem that should concern us. There is ample evidence of this.

At this point, I would like to interpose just a few thoughts about ionizing radiation, for this too is a form of air pollution that can be harmful to health. I mention ionizing radiation because many of the problems which arise in trying to control excessive radiation are distinctly similar to the problems of air-pollution control. Both ionizing radiation and air pollution are relatively new concepts in the public mind; both suffer from disagreements about the establishing of emission standards; both lack adequate numbers of trained personnel; proponents of both have had trouble getting money to pay for minimal enforcement efforts.

The control of ionizing radiation is a particularly urgent problem today. It is urgent because the extent and intensity of ionizing radiation is certain to increase greatly as we grow into our age of nuclear energy, nuclear medicine, and—unfortunately—nuclear weaponry. For this reason, our States should be acting to solve their problems of ionizing radiation right now. Some States already have acted. For those which have not, two points seem pertinent:

Point One: Provisions for radiological control measures can be written into existing State sanitary codes.

Point Two: Control authorities should be organized flexibly at the outset of an enforcement effort. Where financing is a problem, existing personnel in departments of health, labor, and commerce can be combined so as to get under way.

We have ample evidence that both ionizing radiation and air pollution are health problems, economic burdens, esthetic nuisances, and quite likely, social detriments.

What we want to know now is how to reduce present air pollution and prevent new sources of pollution. We want to know what kind of resources we shall need to do the job. And when we have decided this, we must then decide which levels of government can best contribute these resources. Having determined these things, we will then know whose responsibility it is to perform each type of control activity.

To make these determinations of need and responsibility we should prepare a definite plan, and the plan that we devise must be based on current realities. What are these realities? I should say—and quite unequivocally—that the number one reality is this: any plan to control air pollution will ultimately fail if that plan from the beginning neglects to consider public opinion. This is just another way of saying: people come first, and planning—any kind of health planning—must be primarily concerned with the human factor.

We consider people first, because we must never forget that it is people who must first be made aware of air pollution, then convinced of its menace to their health and their pocketbooks. It is people who, following these convictions, will see to it that their elected representatives provide adequate budgets for air-pollution control in State and municipal legislatures.

If people then are the key to the problem, perhaps we should take a brief look at them as they exist today. The first clue toward identifying our Mr. Everyman is to recognize that he displays an intense interest in anything which is likely to preserve his sense of well-being. Some 76 percent of adult Americans today read medical news in their daily newspapers. Of these, 37 percent read all that their local newspapers print of it and want still more. They display similar interest in health and science in other media too—magazines, radio, and television.[2]

But keep in mind that these are the same people who display a massive distaste for attending meetings of their local lawmaking councils, or for volunteering their opinions before any public assembly. Small wonder that they don't; they are the busiest folks on the planet. Each year, 25 million Americans move to new quarters and 10 million change jobs.[3] The American of today, our statisticians tell us, reads more, works more, plays more, raises more children, visits more doctors, dentists, and veterinarians than any other people in the world, past or present. And if he has any time left over after all this peripatetic activity, you can be pretty sure he will spend it in front of his television set. The time spent in front of the television set—this should concern you—averages around 5 hours a day.[4]

These, then, are the people with whom we must deal: a busy, on-the-go species of homo sapiens which holds the joint world's record for having the most informed opinions and the least time to do anything about them. What can we learn from this observation, and how can we apply it to our problem of communicating to Mr. Everyman the need for air-pollution control?

The first and most important thing we can learn is that our Mr. Everyman can be depended upon to show a monumental disinterest in listening to any tedious plans aimed at making air-pollution control a widespread reality. He simply hasn't the time. But don't let this fool you, for remember that he reads and has opinions. He is also greatly concerned about his health and how much his tax bill is going to be, and finally, he holds scientific knowledge in great respect. For all these reasons, he can be intensely interested in seeing that air pollution is controlled, however little he may display concern for how it is accomplished.

All these facets of Mr. Everyman's collective personality are known very well by most of the public officials whom he elects to office. And knowing this, our wiser elective officials know how to proceed. The first thing that they do is to sell their program goals by informing their constituents that a problem exists and explaining how they propose to solve it. Then—if they are very wise officials—they wait for public reaction. If the reaction is mostly silence, they know that they have succeeded in selling their plan. They then proceed to appropriate the money, hire the specialists, and get the job done. These same officials know that the success of their action will not be measured by any public acclaim or civic honors; their only accolade will be a prevailing silence which they may correctly take to mean: "Well done."

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[2] From a survey conducted by the Survey Research Center, University of Michigan, for the National Association of Science Writers and New York University.

[3] From: Radio-TV Documentary "The Hidden Revolution" CBS Presentation; Edward R. Murrow, Narrator.

[4] From: A. C. Nielsen Survey.

If informing our Mr. Everyman is the key to getting enough money to solve our air-pollution problems, then the next question becomes: How do we inform him? This is a how-do-we-start question. Let's approach it by visualizing our educational job as two walls to be breached. We will label the first of these THE WALL OF AWARENESS and the second one THE WALL OF OPINION.

Let us see how we can breach the first one. I strongly suspect that many of the people who read articles about air pollution in their newspapers fail to associate the problem with their local situation. My guess would be that most people link air pollution with "those things that happened in Donora and London."

Therefore, if we are to breach Mr. Everyman's WALL OF AWARENESS we must bring the lesson home to him. We must get him to realize that the air in his own home town may be polluted.

This kind of introductory information should be kept simple. The reason for this is that it must compete for readers' attention with the likes of "Lil" Abner, "Blondie," "Mickey" Mantle, and a favorite football team's latest expolits.

A point can be made too for the light, whimsical touch at this orientation phase of the information process. Psychologists tell us that memory retention is closely linked with the emotional response evoked by the thing to be remembered. This is a pretty fancy statement. Freely translated it simply means that people tend to remember pleasant things and they tend to forget unpleasant things—like air-pollution problems. And if you think that air pollution is not an unpleasant thing for the average man to consider, try reducing it to its basic implications and you come up with something like this: "air pollution is something that's going to make me sick if I put up with it or cost me money if I don't." Faced with these unhappy alternatives, we could hardly blame the average man if he decided to skip the whole subject of air pollution.

That is precisely what we don't want him to do. We want very much for him to read that next article, for it will quite likely be the crucial one—the opinion-making article. So if we've done our first job correctly, we have whetted the appetite of Mr. Everyman so that he is ready for some meatier information on the subject. Now we're approaching his WALL OF OPINION, where the going is bound to get tougher. One reason it will get tougher is because we will need to present him with some facts; cold, hard, irrefutable facts; facts that say loudly and clearly "air pollution is unhealthy, unpleasant to live with, and in the long haul a lot more expensive to put up with than to control." The difficulty of this task is greatly magnified by what we don't know about the effect of air pollution on human health.

Nonetheless, this is the critical phase of the educational program, and because it is critical it must be aimed at all kinds of people. The average man must be convinced that air-pollution control will improve his health, keep his shirts clean longer, and reduce wear and tear on his wife; Mr. Merchant must be convinced that pure air and clean buildings will attract more customers to his shopping area; Mr. Legislator must be convinced that his support of air-pollution control will help to establish or maintain his role as a statesman and thereby ensure his tenure in office; and Mr. Industrialist must be convinced that an optimum amount of source-control equipment in his plant will not wipe out his next quarterly dividend, but instead will result in lower tax assessments, more good will, and less sickness-absenteeism.

As you can see, all this is going to take a lot of convincing. Americans are a nation of Missourians when they are asked to spend money. They want to be shown; so show them we must.

Certainly the best way that we can show them is to provide facts that reach them in readily digestible form. Here are a few of the important questions that demand specific answers in factual statements to the public:

What kinds of harmful pollutants are found in our atmosphere and how does each harm humans, animals, plant life, and property?

Can we determine exactly how much air pollution it takes to affect the well-being of people?

What diseases and disabilities have provable origins in the pollution of the atmosphere?

How much does a dirty, odoriferous atmosphere affect human efficiency and morale?

How much sickness-absenteeism among workers can be attributed directly to air pollution?

Health workers will need to give at least partial answers to these vital questions; with such information we will then have an enormously important educational tool with which to crack that **WALL OF OPINION**. As of now, we have only sketchy answers to some of these questions and no answer at all to the rest. Field and laboratory studies then, we should list as a primary need. And who should assume this responsibility? Certainly the State health departments and university centers can collaborate on such studies. The Public Health Service, Atomic Energy Commission, and other governmental agencies will make major contributions in research and basic sciences associated with this field. But more of that later.

The second important "need" in our educational campaign is to demonstrate the value of air-pollution control by showing what it can do in action. Again, this is a job best conducted by State and local health departments. Pilot control programs in key, selected areas of the State are the essential ingredients of this effort on the State level. This work requires a team of highly-trained technical and professional personnel to carry it out. It will be worth while to enumerate the list of special skills needed at one time or another on this demonstration team, because it will underscore the point I want to make afterward.

This is the demonstration team: physicians, sanitary engineers, mechanical engineers, industrial hygiene engineers, electronics engineers, chemical engineers, and instrumentation engineers; micrometeorologists, botanists, micro-chemists, behavioral scientists, economic analysts, statisticians, administrators; and finally, public information specialists. This is the ideal team needed to do the demonstration job.

But even a modified version of this team can go into a local area and demonstrate what air-pollution control can do when it swings into action. This technique can lift a proposed air-pollution program of a State off its launching pads and give it the initial push that will send it into an orbit circumscribing the entire State.

The dynamics of the pilot program plan follows a cycle that is already well-defined by experiences with other public health programs. Area A is selected as the site for the initial pilot program. The good experience of Area A is publicized throughout the State. This creates public demand for a similar program at problem sites B, C, and D. Legislators from these other places feel the impact of a new demand from their constituents. Final result: the State's air-pollution control program receives acceptance and support and, as a natural consequence, the additional appropriations needed to broaden its activities. Once this sequence is started, it should be properly nurtured by pollution controllers until it reaches an equilibrium that roughly balances the amount of money needed to extend air-pollution control wherever it is needed.

At this point we have sketched out an educational approach which we said was basic to achieving our ultimate goal of optimum air-pollution control. We have not said who should take the initiative—or responsibility if you like—to bring this program into existence.

The major purpose of air-pollution control is to protect human health. To recognize this is to place primary responsibility for starting a program and administering it upon State and local health officers. But air pollution also affects labor, industry, agriculture, and wildlife. For these reasons, representatives of the departments of labor, commerce, agriculture, and conservation can make important contributions as part of the administering authority or in advisory capacities. In 11 States, industrial hygiene activities are not in the State health departments.

But let's get back to this business of starting a program from scratch. We will assume that we have a State or local health officer already aware of his responsibility to get such a program created.

Our health officer, however diligent he may be, knows that he cannot walk into the office of his Governor or Mayor and announce: "we have an air-pollution problem and I'd like some money to solve it."

Before he can present his case for air-pollution control, the health officer must somehow have an air-pollution survey conducted in his area. Remember: he has no money or personnel for air pollution yet. This means he will have to get extra work out of his already overburdened staff or scrape up some money from some private source if he can.

All right, let's assume he succeeds in getting his survey, and the results point quite clearly to an air-pollution problem. Is he ready to present his case? He is not. He hasn't yet determined how he proposes to solve his air-pollution problem. Now he will have to examine what other States or municipalities have done to solve their air-pollution problems: he will have to determine which of these other experiences fit into his area's picture—financially, administratively, and socially. From all this information he is ready to make some shrewd estimates about what type of program best suits his area.

Is he ready now? Sorry, but the answer is still no. He hasn't yet determined what kind of legal authority he has or will need to carry out his program. So he must study existing laws or sanitary codes before deciding what he lacks in the way of authority.

At this stage he is almost certain to find some national and State organizations that are already concerning themselves about air pollution. Not the least among these interested groups will be the inevitable taxpayers organizations. Its primary aim—he will shortly discover—is to nip off any new Government expenditures that might increase taxes. All of these sources will provide the busy, peripatetic health officer with a wealth of useful information, a pretty sound feeling for local attitudes on the subject, and quite possibly, a natural desire to put off this formidable task until some more opportune date in the distant future.

Such desires notwithstanding, the health officer must now sit down with his staff and prepare answers to a number of typical questions he will be asked when he proposes his program of air-pollution control. He may be certain of questions like these: why should the health officer be concerned with air pollution? Isn't this the responsibility of the industries and the municipalities that create air pollution? Aren't there other public health problems more important than this? What proof do you have that air pollution harms humans? How much will this cost us 10 years from now? Where are you going to find the people trained for this work? Why shouldn't the Federal Government do this? And of course, there is always the loaded question: what other programs in your health department will you discontinue to make funds available for air-pollution control?

When he has reasonable answers to all these questions and a host of others—some not quite so predictable—the health officer is ready to launch his campaign to get an initial appropriation and whatever enabling authority he will need. At this stage, he will have to be everywhere at once. He will have to be planning publicity to marshal public opinion among all groups; he will have to be meeting with his Government's chief executive and budgetary advisor to convince these gentlemen that air-pollution control will benefit the public and the administration; if he is a State health officer, he will be meeting with the Governor's counsel and, probably, an interim committee of the legislature to help work out an enabling law; he will be telephoning and writing Public Health Service officials to see if he can borrow some trained personnel to operate a demonstration program and to start research studies; he will be gathering some factual information as ammunition to fire at that tough-minded budget director on the day of financial reckoning.

Which of these moves will come first and which will come last will depend entirely on the local situation. Of one thing he can be certain: he will get no air-pollution control program until he and his staff have worn out some shoe leather, burned some midnight oil, taken the rebuffs of some high-powered executives, and used up a mountain of tact and patience dealing with persons in and out of Government who are opposed to change in any form, shape, or manner. Descartes once said: "The defects are always more tolerable than the change necessary for their removal."

When all of these obstacles have been overcome and the health officer is able to walk proudly into his office with his enabling law clenched tightly in one fist and his appropriation clenched tightly in the other, he can rest a bit. But he can relax only with the understanding that now he must begin planning for the long pull. The first thing the health officer and his staff must document for all to see, understand, and support is a comprehensive and feasible program plan. Here is New York State's approach. The program goals are (1) to prevent the occurrence of new air-pollution sources; and (2) to prevent the progression of existing air-pollution sources.

To accomplish these goals, these three functions must be planned for and executed.

1. Determine the nature, extent, and location of existing and potential sources of air pollution. This is accomplished by:
   - (a) Reviewing, collating, and interpreting existing data from other private and public sources that are pertinent to the State and its communities.
   - (b) Conducting field studies and surveys which can indicate how much of what substances are emitted in the air, and when, where, and by whom they are emitted.

2. Apply effective methods of control and prevention within the limits of State and local resources in priority areas and where chances of success are high. This can be done by assisting communities and industries:
   - (a) To plan, execute, and evaluate their control programs.
   - (b) By extending consulting services, loaning personnel, conducting demonstrations, making grants of equipment, and if available, funds.
   - (c) By Statewide public education through community organizations and mass media in cooperation with voluntary health agencies, industry, and other State departments.
   - (d) By developing State and local codes, ordinances, and regulations for standards and enforcement.
   - (e) By developing inspection programs and using community resources to ensure enforcement.
   - (f) By operating a training program for State and local personnel.

3. Establish and maintain research programs to develop better methods of control and better instruments to measure air pollution with, and to gain new knowledge in all phases of air-pollution prevention and control.
   - (a) By departmental research activities.
   - (b) By contract with other State departments, universities and colleges, industry, and private groups.
   - (c) By joint research projects with the Federal Government and other national agencies.
   - (d) By program evaluation through operational research at regular intervals. From this program plan, the health officer can work out the managerial and administrative activities and time schedules that will enable him to accomplish his goals.

This then, is the program of action. I believe it is a sound program because its primary focus is on people and on helping them to think and act in the best interests of their health.

Action programs work out best when they are decentralized to the local units of government. Some units are too small to provide the funds or staff; others do not readily accept their responsibilities. In either instance the State may have to step in to accomplish the task until such time as a local community, if able to, can assume its rightful role. The State should provide its share of the funds required locally and concern itself with overall planning, consultation, evaluation, and research. This policy preserves Federal-State-local relationships that characterize our democracy. It is also the only sensible way to pinpoint areas of responsibility among various levels of government.

By now, there must be one overriding question which is troubling most of you. Many of you are probably asking yourselves: "If air pollution control can be achieved by the method outlined, then why don't we have effective control programs everywhere they are needed?"

This is a fair question. I will answer it by reminding you that air-pollution control is still a relatively new concept as far as our Mr. Everyman is concerned. Its proponents have yet to impress on the public mind that it makes good sense healthwise and moneywise. In doing this, they must compete for public attention with a host of other needs that have already been more highly publicized and adequately demonstrated as being worth the money. Some of these other needs—to mention a few—include new highway construction, school construction, teacher recruitment, and urban redevelopment. All of these needs have long since penetrated both Mr. Everyman's **WALL OF AWARENESS** and his **WALL OF OPINION.**

Most of our States and communities are hard pressed to find enough money for these and other needs, and they are already persuaded that they must. Faced with pleas to do something about air pollution, many States and communities can provide little more than token gestures of financial support. These token gestures are seldom adequate to recruit and train enough personnel; they are seldom enough to equip research laboratories adequately; they are seldom enough to finance administrative costs and public information programs. Without at least a minimal effort in each of these diretcions, an air-pollution control program cannot even begin to crawl, much less to walk.

The real question we should be asking ourselves then, is this: How can we get our States and communities started in a big enough way so that the impetus of their initial control effort will be enough to carry it through to completion? Those 66,400,000 automobiles I mentioned at the beginning of my talk could not budge an inch unless they had starter motors. In the same way, many of our States and communities need some kind of a "starter motor" to get their air-pollution programs under way and rolling.

The starter motor that I should like to propose to you at this point is this: a crash recruitment and training program in air-pollution control by the Public Health Service. Such a program should be similar in scope to the crash programs of the Public Health Service in venereal disease in 1936 and tuberculosis in 1944. These programs achieved dramatic results in slashing morbidity and mortality rates of these one-time major threats to health. The primary emphasis of these crash programs was in loaning personnel to help States and communities to set up effective venereal disease and tuberculosis control programs.

This same kind of massive effort is called for today if we are to get our States and communities started in effective programs of air-pollution control. If this is not done, and soon, irreparable damage can result. In proposing this, I am indeed aware of the significant contributions already being made by the Public Health Service in air-pollution control. A review of these contributions serves to underscore how much more can be done to achieve a major break-through in air-pollution control. But to accomplish this, the Public Health Service must first have the go-ahead signal from Congress, for a vastly expanded recruitment and training program.

In summary, impetus is the key to the present air-pollution problem. States and communities will be dangerously slow in getting under way unless trained personnel become available. The Public Health Service can recruit and train personnel on an emergency basis better than any single State. The magnitude and complexity of the air-pollution problem does not permit any avoidable delay. The health of all our people—not just a selected few—is at stake. State and local health departments know that they can demonstrate both the need for air-pollution control and the method of accomplishing it if they can obtain the trained personnel. Once they are given a start by the Public Health Service, they will assume their appropriate share of the work and the cost. Past experiences in venereal disease, tuberculosis, cancer, and water-pollution control—just to mention a few—have shown that this Federal-State approach is sensible, economical, and timesaving. Air is a precious and precarious national resource. Without it, we cannot remain healthy or strong. Let's get on with the job.

Public Interest Demands Clean Air

Thomas H. Kuchel
U.S. Senator, California

Presented by Warren B. Francis
Staff Assistant to Senator Kuchel

Several recent days of intense personal discomfort in the choking atmosphere which sometimes envelops Los Angeles make me intensely aware of the deep importance of this conference.

So, as a recently-escaped smog refugee, I welcome this opportunity to engage in thinking-out-loud on the matter of the public interest in air pollution. I appreciate the invitation to present some personal reflections to this assembly because of the inescapable fact that the communities in which I have spent most of my entire life often are painfully plagued by contaminated air in its worst form.

This conference is unmistakably a significant event. Scientific and technical problems of great moment will be discussed and examined in the earnest hope, I am sure, of promoting the public interest and serving the public welfare.

There is no question in my mind that public interest is the overriding consideration which must be the goal of all efforts to overcome the curse of air pollution. Certainly there can be no private interest, especially from a pecuniary viewpoint, in prolonging smog and other atmospheric contamination.

All of you present are aware that this meeting is occasioned by the fact that a little more than 3 years ago the Congress enacted legislation known as Public Law 159, the Air Pollution Control Act. By that measure, the Federal Government entered the fight to identify causes of air pollution, and an assortment of Federal agencies became allies of public and private, State and local bodies endeavoring to conquer this public enemy.

The enactment of this legislation was no simple accomplishment.

Unfortunately, for a number of years, smog was regarded as a unique Los Angeles phenomenon. Comedians attached to it a made-in-Southern-California label.

With the passage of time, and after the laughs became strained, our Nation gradually and thankfully came to the realization that air pollution is one of the distinguishing, built-in, undesirable features of the growth and advancement which our country has been enjoying.

The progress of all agencies operating under the Air Pollution Control Act is of deep concern to me because I authored that act. The conclusions of this conference will be equally meaningful to me because my interest in removing this curse of our industrialized, motorized civilization is of long duration.

When I first came to Washington as a new Senator appointed by the then-Governor of California, Chief Justice Earl Warren, I early attempted to bring about Federal participation in the fight to eliminate smog. I did this because my experiences as a State official indicated plainly that the problem has so many ramifications it must be attacked on a nationwide basis.

Personal exposure to the discomfort and the inconvenience from day-long sieges of greasy, eye-irritating murk encountered in Los Angeles undoubtedly has strengthened the determination of many of you here today—as it did me—to employ all of the resources of our great Nation in eradicating a scourge which menaces the physical health and well-being of millions of Americans, which causes vegetables and fruits to wilt and shrivel, which brings property deterioration, which adversely affects livestock, and which triggers a host of economic consequences.

The public interest in air pollution at that time was not so widely appreciated in Washington as to bring success to the first efforts in which I participated. Happily, however, the public interest had attracted the attention of the people in the executive branch of our Government. It was a matter of considerable satisfaction to me, therefore, when President Eisenhower, in response to a suggestion I made in association with my colleague, Senator Homer Capehart of Indiana, formed what carried the formidable label of "Ad Hoc Interdepartmental Committee on Community Air Pollution."

Even though smog still occurs, millions of people should be eternally grateful for that committee, because from its deliberations resulted the legislation which I introduced, with the cosponsorship of several Senate colleagues from divergent areas who agreed that something must be done.

Underlying all of my thinking and my conversations was a conviction that actual control over air-pollution sources and causes was and must be a local and a State responsibility. This view was shared by all of those who took part in framing and pushing through the Air Pollution Control Act. Throughout, the principle has been observed that the Federal Government should not and cannot impose or enforce regulations designed to prevent air pollution, regardless of how desirable such activity might at times appear.

Yet, the Federal Government has a natural and a proper role in our national war against smog and other forms of atmospheric pollution. It has unequaled resources and unmatched experience in the field of meteorology, for instance. It has immediate access to basic statistics assembled from every corner of our country on health conditions. It is in an unmatched position to coordinate investigation and research. It can mobilize from assorted sources skilled scientific and engineering personnel.

Those are among the reasons why I wanted the Federal Government to play an active part in the smog fight. Those are the reasons why I am prepared to introduce next year new legislation which will implement, extend, and carry forward Public Law 159, under which present work is carried on.

As a Californian from a semiarid region, I long have been aware of the precious character and the imperative necessity of adequate water supplies. As a human being, I likewise know that clean air is basic to existence, comfort, and happiness. As a southern Californian I also realize that my section of the country unfortunately has encountered serious and prolonged difficulty in assuring itself of a sufficient, reliable supply of both clean air and clean water.

Those grave needs are not peculiar to California. Today they are nationwide in scope. With constant and steady increase in our population, with characteristic continuing movement of people, with development of an economy almost wholly dependent upon industrialization and motorization, the public interest demands basic fact-finding which will make possible sound measures to conserve, and to prevent pollution of, air and water alike.

Regrettably, despite startling achievements and amazing discoveries, science has not yet found a way to purify air in quantities or with the ease with which we do water. We must reduce and, to the maximum possible, prevent contamination of our atmosphere.

When a room becomes smoke-filled, one generally can open a window or turn on a blower. But no one yet has come up with a means of lifting a veritable ceiling over an entire metropolitan area, which would be the only way of ventilating a community filled with smog of the sort which occasionally plagues many American cities. We still do not know how to sweep away what meteorologists call inversion layers of superheated air which serve as a lid over our steaming kettles of closely-packed people.

The lack of a window to bring in sweet, fresh air to whole communities is the justification for control measures such as have been adopted in several regions of California. Such regulatory procedures have a palliative effect and have been evolved through costly and painful trial-and-error approaches. In many instances, they have been remarkably successful. Yet, they have not solved the problem because the problem itself is so complex.

Unfortunately, a permanent solution apparently still is some distance off. Hence, the significance of this conference.

Congress will be guided by the conclusions of this meeting. Our committees will be indebted for your evaluation of the progress made thus far, for your criticisms and your recommendations about the future course to be followed.

We on Capitol Hill are highly conscious that our people want relief from the curse and the menace of air pollution. Daily it is made plain to us that the human stake in this fight is great, because of the tremendous price our Nation may pay for continued contamination of the air all of us breathe, every moment of our lives.

The American people have been disturbed by reports of qualified medical observers that air pollution has harmful effects on persons with respiratory troubles. Is it any wonder there also is grave concern among our populace, which repeatedly undergoes irritations of eyes, noses, and throats?

From many quarters comes evidence that smog causes slums and upsets the balance of communities. Foul, polluted air influences our citizens in building homes and selecting places to dwell.

The public interest in the war on air pollution has reached the point where monetary, selfish aspects cannot be ignored. Take, for instance, the situation in Los Angeles County, where constituted authority can order a shutdown of industry and a cessation of motor traffic when smog reaches a specified degree of intensity.

The costs of such counter-measures are incalculable, but they are beyond question tremendous. Businesses and industries, particularly small enterprises, cannot long afford to absorb the expense entailed by drastic action to curb pollution of our air. Yet, until we learn the secrets of what causes smog, we are merely fumbling in our attempts to prevent its occurrence.

Even though periodic shutdowns because of "smog alerts" may be infrequent or brief, a community which gains the reputation of being afflicted by serious air pollution inevitably loses its appeal to tourists and visitors. Unchecked continuance of atmospheric contamination eventually and undeniably will halt the growth and progress of any community as surely as a Chinese wall around its perimeter.

The urgency of identifying every single source of pollution and of laying bare all secrets about the mystic natural forces which cause smog is emphasized by the fact that effects of contamination can be and often are far-reaching. Counties surrounding heavily-populated cities are not immune since the vagaries of the winds can roll clouds of fumes across man-made boundaries. Contiguous territory from which come food supplies no longer is unconcerned, following discovery that some 40-odd separate crops can be injured by polluted air.

Problems of such character cannot be solved at local levels. Nor can public agencies of Government—whether State, Federal, county, or municipal—cope with all the factors. Active cooperation of industries and private organizations is essential.

We are fortunate indeed that some of our leading enterprises, notably the petroleum and the automobile industries, recognize the serious implications in the presence of air pollution. Their efforts to help check the menace have been substantial and are most commendable. Yet, they and others with related interests continue to have a public obligation to work unceasingly in the public interest in finding means by which aerial garbage will be eliminated from our environment.

For their own welfare, the petroleum and automobile industries cannot shirk their responsibility. Already public clamor has been heard in some quarters for action on the part of constituted authority which would have heavy consequences to those industries. Though scientists may scoff, none of us should lightly regard a wave of suggestions that certain types of motor fuels be prohibited by ordinance or regulation. We cannot overlook the resolutions now reaching Washington urging Federal promulgation of standards governing the emission of hydrocarbons and other products of combustion.

The program envisioned when Public Law 159 was enacted was to be of 5 years duration. The authorized total expenditure was to be $25 million. Our Federal agencies now are in the fourth year of that program. The Congress has so far appropriated for the program almost $12 million. A host of research and investigation projects has been set in motion.

This law expires at the end of fiscal year 1960. Hence, it will be incumbent upon the Congress in its forthcoming session to decide whether activities should be halted or the law extended. For my part, I am convinced the act which I sponsored should be continued in effect and I wonder if possibly it should not be broadened.

I regret that more funds have not been made available. However, there were forceful reasons and circumstances for limiting the appropriations. But our people, especially those who undergo from time to time the irritation and inconvenience of smog occurrences, now and then wonder whether the expenditure has been sufficient. Others question whether it has been worthwhile.

It is difficult for the man in the street to appreciate the proportions and the complexity of the air-pollution problem. This conference has a rare opportunity to reassure every citizen that we are expanding our knowledge and that we are pressing forward for his relief with undiminished determination.

This is vital, because the people of America, from the earliest moment of comprehension, believe in free air.

More and more, it is being demonstrated that freeness is relative.

Just as we have seen water supplies in various regions near the point of exhaustion, so must we awaken to the fact that our supply of pure air is in real danger of running out.

Public apprehension about effects of radioactive fallout—notably about what might happen when and if—has been expressed often in dramatic fashion. Yet the insidious influence of air pollution right now is a present and a continuing threat to physical and economic health.

Air is a natural resource and like all natural resources must be husbanded and conserved with all the ingenuity and determination we possess.

Public and private agencies join hands to solve the increasingly acute water problem. Local irrigation districts participate with the Federal Government in building dams and reclamation projects. Our Department of the Interior shortly will embark on an ambitious program of erecting full-scale field test plants for converting saline water to sweet, potable supplies for municipal, agricultural, and industrial uses.

The problem of air pollution is of comparable importance and warrants similar earnest mutual attention. Perhaps it should receive a higher priority. For, without fresh, uncontaminated air, people will not congregate or remain in thickly-settled communities. In that event, the demand for ever-larger water supplies might easily be altered.

The foundation for future growth and development of many American communities may well rest on solution of the smog problem. Suggestions already have been thrown out that air zoning be undertaken. This would attempt to make certain that industrial expansion—vital and welcome as it may be—is so directed as to take advantage of prevailing winds or features of terrain in reducing potential air pollution.

Likewise, the public stake in cleansing our atmosphere may warrant radical innovations in traffic engineering. Admittedly, our Nation as a whole, and most of its major cities, confront real headaches in constructing and rebuilding streets, highways, freeways, and other arteries to handle the furiously-mounting traffic volume. But unless other means can be found to control the way mechanical horses emit foul-smelling breaths, it is conceivable that we one day will ask engineers to channel fume-spouting automobiles, buses, and trucks away from smog-prone centers.

The obvious public interest in relieving air pollution appears to be multifaced. In promoting that interest, I sincerely trust this conference will be dedicated to the principle of pooling resources in the traditional American fashion so that the public welfare may be benefited to the greatest degree of which we are capable.

Social Aspects of Air Pollution

Dr. Chauncey D. Leake
Assistant Dean, College of Medicine
Ohio State University, Columbus, Ohio
Representing the American Association
for the Advancement of Science

The purity of the air we breathe is a basic right we all acknowledge. In order to maintain it we have to work together, all of us, all over the world. Individual and group responsibility for the purity of our common air makes this matter a social problem, of interest to society generally, in every part of the world. The social aspects of air pollution concern every one of us, as individuals and as citizens of the societies in which we live.

Air pollution was of little significance before the industrial revolution which has been exploding since the late 18th century. Yet even primitive peoples were quick to realize the importance of keeping down smoke from fires or dusts from traffic. Good air was sought in making settlements, and the ancient Greek physicians of the Hippocratic School appreciated the value of good air in preventing disease.

Vitruvius, the great Roman architect under Augustus, gave detailed instructions for the ventilation of buildings to assure wholesome air. He even had a glimpse of what green plants might do in keeping good air in cities, for he recommended tree-lined streets, to help keep fresh air in crowded areas.

The popular (or social) fear of bad air as a factor in disease is reflected in our word "malaria," the fever long associated with polluted and stagnant dank places. The smog of cities was known in the Middle Ages. It became commonplace as populations increased. Edinburgh was long known as Auld Reekie from its belching chimney pots, and London fog became notorious as industrialization expanded.

By the beginning of this century, smog had become a civic calamity for Pittsburgh. It was excused as an index of prosperity, notwithstanding personal discomfort and housekeeping expense. Air pollution was distressing in Chicago, St. Louis, and Baltimore. When soft coal replaced anthracite for home use and industry during World War I, New York City and Philadelphia began to suffer.

Gradual replacement of coal by oil and gas seemed for a while to reduce the grime. There was improvement in bad spots like Pittsburgh and St. Louis, especially when Cottrell smoke-precipitators were installed in the black belching stacks of industry. These became acceptable to industry either through enlightened management or as a result of social pressure. But in some small communities the smoke ruined all, as in Perth Amboy, where no one seemed to care.

Since World War II, however, there has been a steady rise in air pollution of cities, recognized all over the world. That keen word, "smog," has been most publicized in Los Angeles, where even the chamber of commerce could not hide it. But it was also noted around San Francisco, around Houston, over Cleveland, Boston, Birmingham, and Buffalo. Those who traveled by air could easily spot it, trailing from stacks and hanging over cities everywhere, from Liverpool to Moscow, from Milan to Osaka, from Detroit to Sao Paulo.

The really serious social aspect of air pollution came dramatically with the thousands of deaths in London in the black smog of 1952, in the disasters of Poza Rica in Mexico, of the Meuse Valley in Belgium, and of the Donora Valley in Pennsylvania.

Meanwhile a highly controversial social aspect of air pollution came with nuclear weapon testing. Here is a subtle, not easily seen, but potentially very dangerous sort of air pollution, involving all living things, now and to come. One has only to spend a day or so in Japan to realize how serious a social aspect of air pollution this can be in terms of human fear and anxiety. The Japanese people, most of them quite innocently, have really tasted it.

One need only spend a few hours in California or in Nevada to recognize the growing public apprehension over radiation fall-out. Unfortunately, the confusion over security matters has weakened popular confidence both in the pronouncements and in the judgment of the Atomic Energy Commission. Here is an instance where failure of satisfactory communication between a scientific agency and the people has resulted in serious social disturbance. Let this lesson be clear to us in regard to other aspects of air pollution.

Social Factors in the Scientific Aspects of Air Pollution

With contamination of the air we breathe a subject of individual and social concern all over the world, it is heartening that there finally has come wide scientific activity directed toward understanding the physical-chemical factors involved, so that effective and generally satisfying control may be instituted. We all want pure air to breathe. We need it. It is the business of scientists to tell us how this can be obtained. It is the business of all of us to apply the scientific knowledge we can get on air pollution to the simple proposition of conserving pure air for all of us and for our descendants.

Here is a job on which every one of us may work together to accomplish what is necessary for us all. In this job no vested or selfish interest, whether individual, commercial, advertising, industrial, political, or national, can be allowed to stand in the way, if we all really want the pure air we must have if we are continue to live heathily.

Thanks largely to the stimulus of the Los Angeles Air Pollution Control District, which was organized and functioning soon after World War II, we have a large amount of detailed scientific information on the multitudinous and surprising factors contributing to smog. This has been skillfully and wisely analyzed by Prof. A. J. Haagen-Smit.[1]

The example set by Los Angeles has been followed by efforts at control of air pollution by most of the major American cities. In some places the results are impressive. In others official apathy or special privilege nullify the program. In Cincinnati there is a broad research program, supported by the U.S. Public Health Service, at the Robert A. Taft Engineering Center. Here it has recently been shown by R. N. Mendenhall and his associates how air contamination, particularly from automobile exhaust, leads to an extraordinary complex of an amazing number of highly irritating and toxic volatile chemical agents. A bread program of study on air pollution has been well conducted by Dr. H. H. Schrenk in Pittsburgh, Pa.

The Committee on Social Aspects of Science of the American Association for the Advancement of Science has considered pollution of airs and waters to be among the most serious social consequences of the current scientific explosion. We planned a general symposium to discuss pollution of airs and waters. Lack of funds and of staff made it difficult to organize the effort. We are grateful indeed that Surgeon General Leroy E. Burney of the Public Health Service of the U.S. Department of Health, Education, and Welfare called this conference to consider this problem, and to try to reach agreement on the best ways of solving it. Wisely also did the Assistant Surgeon General, Mark Hollis, dramatically call the situation to public attention by a carefully considered, cautiously worded, and solidly informative interview, which was widely circulated.[2]

The Public Health Service is clearly taking the lead, as we all recognize it should, in affording an opportunity to consider all the factors concerned in air pollution and to plan ways and means whereby contamination of the air we breathe may be brought satisfactorily under control.

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[1] A. J. Haagen-Smit, Air Conservation, Science, 128: 869–878, October 17, 1958.

[2] Mark D. Hollis, Fresh Air Getting Scarce in U.S.?, an Interview in *U.S. News and World Report*, October 17, 1958, pp. 70–81.

Factors in Air Pollution and Their Consequences

The various physical-chemical factors involved in air pollution include dusts, some of which are radioactive, soot, carbon particles, ash, oxides of carbon, of sulfur, of nitrogen, and of many metals, mixed hydrocarbons, aldehydes, ketones, organic acids, and the highly irritating ozone.

Under the action of sunlight, heat, water vapor, and atmospheric conditions, a complex of organic compounds may develop, some of which are carcinogenic. Ozone and the compounds which it can produce may cause widespread trouble for all living things in the area, with local irritation of eyes, of nose, and of respiratory organs. These may also injure all growing things, and cause damage to machinery, and to any type of rubber material. They may act in very small concentrations, involving only a few parts per million of air. What may happen if the concentrations tend to increase?

Mendenhall and his associates from Cincinnati find that tolerance develops to the acute effects of ozone and of ketene, but how about the danger of continuing inhalation of small amounts of these toxic agents every minute of every day, year after year?[3]

Most of air pollution is referable to combustion. This was realized centuries ago. England had laws regulating the burning of coal in the early 19th century. Air pollution from burning has nevertheless steadily increased with industrialization. Now, however, as Haagen-Smit shows, about half of air pollution is referable to exhausts from internal combustion engines in automobiles. Here is a challenge.

In Seattle, autos and trucks dump 160 tons of hydrocarbons, 32 to 80 tons of nitrogen dioxide, and 4 tons of sulfur dioxide into the city's air every day. When are the auto and truck manufacturers going to turn from the foolishness of fins, from silly style whims, from over-sized models, and from too much horsepower, to the essential but tough job of controlling exhausts?

This is a pressing matter to each of us personally, and to our community society. In addition to eye and respiratory irritation, the increasing incidence of lung cancer is quite as referable to increased city auto traffic exhausts as to cigarettes. Russian public health officials, I learned a couple of years ago, claim their rising occurrence of lung cancer in the cities goes along with the increase of auto and truck traffic.

What about the tremendous increase in the blanket of carbon dioxide that we are throwing above us, and which will inevitably tend to increase heat capture from the sun? What will we do if this occurs, with gradual melting of the huge polar ice caps, and the gradual rise of our oceans, drowning out still further our shore lines?

Perhaps we can prevent possible accumulation of carbon dioxide, which even in a very slight degree may alter the extent of heat capture, by extensive planting of trees and other green things. Maybe 10 trees planted for every automobile, with 100 for every truck, would help. Our cities could certainly benefit from such tree planting, regardless of their possible aid in reducing the contamination of the air we breathe.

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[3] R. N. Mendenhall, Tolerance and Cross-Tolerance Development to the Atmospheric Pollutants, Ketene and Ozone, Ohio Valley Section Society for Experimental Biology and Medicine, Columbus, Ohio, October 31, 1958.

The increasing urgency of our common air-pollution problem may be gaged from the detail to be offered by this conference. The status of current knowledge on air contamination will be broadly reviewed by Herbert McKee, "What's In the Air?"; Leslie Chambers, "Where Does It Come From?"; James Dixon, "What Does It Do To Us?"; Reuben Gustavson, "What Are the Costs To Us?"; and Charles Gruber, "What Can Be Done?" There will be a survey of accomplishments by control agencies, and significantly, we will hear from industries on plans for the matter. Details will be considered on the extent of air pollution, on the sources, on the health effects, on economic and social effects, on control methods and procedures, and on administrative problems.

Then what? Will this all be neatly printed in a thick volume, to be filed away and forgotten? After all, what was accomplished by the interdepartmental conference which was so well organized in 1950, by Dr. Louis McCabe? Certainly a conference like this can mean much to our social organization, and to us individually, if we can somehow communicate to the people generally what we are talking about.

The Los Angeles Air Pollution Control District has given an excellent example of how the essential facts about air pollution, with their consequences for individual and social welfare, can be communicated to the people. In Los Angeles skillfully prepared informative pamphlets are freely available in public buildings, transportation centers, and in many large stores. The newspapers cooperate very broadly, and there is excellent support from local TV and radio channels. This kind of example might well be followed more generally. Nevertheless, if air pollution is successfully to be reduced, we all have to get busy and actually do something about it, or else we are all going to continue to suffer from it.

To close my rambling comments, it might be remembered that the social factors of the scientific aspects of air pollution are mainly concerned with getting the facts to the people, obtaining understanding of the individual and social consequences of the facts, and then securing motivation to get busy and help clear the situation. The responsibilities in the manner of air pollution are individual as well as social, political, and industrial. Let's make sure that the discussions of this conference are as widely distributed as possible and that there may be effective translation in popular language of what we talk about, so that the people generally may benefit from the recommendations that may be made and the agreements that may be reached.

Technical Aspects—The 1950 Assessment

Dr. Louis C. McCabe
President, Resources Research, Inc.
Washington, D.C.

Many of you gathered in this same place more than 8 years ago at the U.S. Technical Conference on Air Pollution which was called by the President "for the purpose of summarizing our knowledge of this difficult subject and . . . preparing recommendations for cooperative effort of public and private interests to minimize atmospheric pollution and its ill effects." The President directed that the most highly qualified persons in this field in industry, government, research institutions, and other lines of endeavor should be invited to participate and that a report should be made available to the public. Ninety-seven papers were presented in seven panels grouped under agriculture, analytical methods and properties, equipment, health, instrumentation, legislation, and meteorology. Publication of the proceedings brought together in one volume an authentic body of information on the nature and control of air pollution.

The subject of air pollution was not new for there were many examples in the years prior to the 1950 conference of the successful application of the scientific method to specific atmospheric contamination problems. Great emphasis had been placed on smoke prevention for a long time but only recently had there grown up a store of theoretical and applied information which could be employed in air-pollution work. Much of this information grew out of research and development programs of the civil and military agencies of government, the universities, and industry.

In the course of the discussions there were papers on the characteristics of aerosols and methods of determination of particle size and number. The limitations in the use of the light microscope and the electron microscope for characterization of particles were discussed. The changes of air pollutants during dispersion and during collection were noted and it was observed that when two chemicals are dispersed each may not be of any great importance, but the combination of the two in the air may be of serious consequence. This phenomenon encountered in dispersion was also a major problem after collection. The need for the development of methods for measuring air pollution in situ or analyzing for the unchanged molecule was recognized.

By 1950 the high overall oxidizing power of the Los Angeles atmosphere had been established in contrast to the reducing atmospheres of many other metropolitan centers. Haagen-Smit had shown that in the presence of sunlight, ozone and hydrocarbons formed a dense aerosol having such similarities to Los Angeles smog as its oxidizing capacity and eye-irritating effect. Peroxides, aldehydes, and acids had been identified as significant in this type of air pollution. The need for further knowledge of organic pollutants was apparent.

The sulfur-bearing contaminants held a special position in nearly all air-pollution investigations and the analysis and collection of sulfur-containing components, such as sulfur dioxide, hydrogen sulfide, and mercaptans were of particular interest. Two continuous automatic recording instruments, one employing titration and the other measuring the change in electrical conductivity of a solution, had recently become available.

In the years just prior to 1950 there was evidence of great and varied activity in the meteorological phases of air-pollution problems. The distribution of pollution from a single source had been studied both theoretically and experimentally for various meteorological conditions. Progress had been made in the study of pollution from multiple sources, such as those of a city. Valuable information had been gained concerning special factors such as diurnal variations of diffusion, frontal surfaces and subsidence inversions aloft, deposition and coagulation of particulate matter in the atmosphere, and topography.

The meteorologists expressed a need for standardization of instruments and procedures, the theoretical development of the subject, investigation of the diffusion of effluents in a city, micro-meteorological and micro-climatological surveys of cities and their suburbs, correlation of meteorological variables with a continuous record of the magnitude and location of pollution, observations of temperature gradient and wind in the lowest 500 feet of the atmosphere, and organization and publication of existing and current literature.

Collection of contaminants at the source was a subject of considerable interest 8 or 10 years ago as it is now. This was a period of increased use of fibrous and energized collectors, bag-type filters, bubble towers, and packed towers. Cyclonic spray towers and the Venturi scrubber had received novel application. There was increased use and research by several companies of one of the oldest devices, the electrostatic precipitator. The power industry was very active in stoker and furnace design and in the installation of precipitators and dust collectors. The characteristics and usefulness of high stacks had been investigated extensively abroad and in this country.

There was the belief that we had plenty of equipment for most any specific problem but that we lacked definitions or standards of air cleanliness which would facilitate intelligent development, design, selection, and use of the equipment.

In 1950 the division of health of the city of St. Louis determined the sulfur dioxide concentrations to compare them with concentrations encountered in 1936–37, before the new smoke regulations were in effect, and to learn something of the meteorological factors affecting volatile sulfur compound concentration. The average reduction in the sulfur dioxide content of the St. Louis atmosphere from 1936–37 to 1950 was 73 percent in the summer and 83 percent in the winter. The factors probably contributing to this reduction were requiring the use of low volatile coal in hand-fired heating plants, washing of solid fuels to remove high sulfur refuse, change-over from coal to oil or gas, and dieselization of railroad locomotives.

U.S. Weather Bureau observations in Pittsburgh in 1950 as compared to 1945 show considerable reduction in the intensity and duration of smoke. During this period the annual smoke total was reduced 67 percent, the annual heavy smoke, 77.3 percent, the heating season total smoke, 84.8 percent, and heating season heavy smoke, 94.8 percent. The deposited matter, averaged from 8 dustfall cans, dropped from 60 tons per square mile in 1938 to 55.3 in 1948, 51.5 in 1949, 50.3 in 1950. Ely estimated that Pittsburgh's annual saving due to greater cleanliness is nearly $27 million or $41 per person; the greater part of this, or nearly $17 million, is saved in domestic buildings. Much of the reduction in smoke is due to more efficient combustion so that further savings accrued because of fuels savings; this was not taken into account, although it may well have been greater in amount than the $27 million due to greater cleanliness.

The more important causes of the reduction of atmospheric pollution in Pittsburgh were:

1. Prohibition of high volatile fuel.
2. Promotion of more efficient combustion, which is considerably assisted by the equipment-licensing requirements.
3. Replacement of the majority of steam locomotives, especially those used for switching, by diesel engines.
4. Reduction of industrial emissions by control and collecting methods or by redesigning processes.

The agriculture panel in 1950 was top-heavy with fluorine studies because fluorides were in the news. Sulfur dioxide had been studied and restudied and was very well labeled as far as agriculture was concerned. With fluorides we were not so well informed and there were many controversial issues as to its effects on livestock and plants. Dr. Moyer Thomas described the damage when smog of the Los Angeles type stands over plants for a considerable period of time. Dr. Zimmerman discussed mercury, ammonia, chlorine, hydrogen sulfide, carbon monoxide, unsaturated hydrocarbons, and growth-regulating substances as air contaminants. He pointed out that the task of evaluating plant injury is not an easy one for the experienced person and is one beset with pitfalls for the inexperienced worker.

Certain trends had become clear in legal opinion by 1950. One of them was the feeling that the Federal Government should not enter into policing the State problems of pollution of the air. In contrast there was the feeling that the Federal agencies, independently or in collaboration with the State and local bodies, should undertake investigations and research on problems of air pollution. It was pointed out, however, that from the legalistic and legislative standpoint, air pollution does have certain aspects that transcend the purely local interest. The Trail Smelter case and the Detroit-Windsor problem were cited as examples of air pollution involving both the Canadian Government and the U.S. Government.

There were several bills in the Congress in 1949–50 which proposed appropriations for investigation and research. One of them would authorize the Civil Aeronautics Board to investigate smog in the vicinity of airports. Another would have authorized the Public Health Service to investigate the problems of air pollution with respect to health. There was also a proposal that the Federal Government advance the control of air pollution by tax adjustment. The very large expenditures that industry must make in many cases to eliminate air pollution are necessarily charged off as capital expenditures. Revision of the tax structure to enable industry to charge off such installations as expense was therefore favored.

The American Society for Testing Materials, Committee D-22 on Methods of Atmospheric Sampling and Analysis, was organized toward the end of 1950. This same year the Smoke Prevention Association of America, organized in Chicago in 1907, became the Air Pollution and Smoke Prevention Association of America. It was on its way to shed its vestigial tail to become the Air Pollution Control Association in 1952. The Manufacturing Chemists' Association formed its Air Pollution Abatement Committee in 1949 and began work on its comprehensive manual, which was published in 1954. The Coal Producers Committee for Smoke Abatement began providing technical services to cities and other coal consumers in 1941. As early as 1934 a committee of the American Society of Mechanical Engineers began to develop suggested limits for smoke and fly ash. The work of this committee was published in 1942 as the Model Smoke Code and subsequently was incorporated in many city ordinances.

The health panel of the 1950 conference was concerned with (1) the effects of relatively severe exposure to air pollutants for short periods of time and (2) the chronic effects from continued exposure over long periods of time to low concentrations. In brief summary of the information presented in 14 papers, the following points are outstanding:

1. The pollution of the atmosphere with allergenic material of natural, artificial, and industrial origin is associated with a frequent, and apparently increasing, occurrence of acute and chronic disease, involving especially the respiratory tract and the skin.
2. Certain acute manifestations, caused primarily by respiratory or ocular irritation, have been observed in association with industrial operations and accidents and unusual weather conditions in localized areas.
3. The effects of the more common atmospheric pollutants upon the general health of the population of our urban and industrial centers have not been demonstrated in the form of authenticated chronic disease processes.
4. The complexity of the problem is such that further evidence must be sought before the hazard to public health can be appraised adequately.

This, in brief, is an assessment of the technical aspects of air pollution as it was in 1950.

Conference Objectives

Dr. David E. Price
Assistant Surgeon General
Public Health Service

In retrospect you will probably recall these last 2 hours as the easy part of this conference. The previous speakers have told you about achievements to which many of you have contributed, and have fired our imaginations with the challenge of the future.

It now becomes my brutal task to lead you down from these sunny mountain tops, down to the specific and difficult jobs on which you will be working for the next 2½ days.

The title of my talk, "Conference Objectives," is just a euphemistic way of telling you how tough a job we are handing you and how much we are expecting of you.

Dr. Burney has already mentioned one of our expectations, a dispassionate appraisal of the Public Health Service program under Public Law 159 and your best judgment as to our logical future course of action. In my capacity as chief of the Bureau of State Services, I personally will view your evaluation of the Federal program with especial interest. The resources of this Bureau include the medical and the engineering air polution programs, and the sanitary engineering and occupational health centers in Cincinnati, all of which are engaged in air-pollution activities. Our regional offices, which serve as points of contact with State and local programs, are another avenue through which our air-pollution activities are channeled. In brief, the Bureau of State Services is the operational arm of the Public Health Service which carries major responsibility for all of its air-pollution work and will be most influenced by the conference findings.

But this analysis of the Public Health Service program is only one part of the task we are laying before you. We hope you will examine with equal care industry's responsibilities and its successes and failures in carrying them out. We hope you will assess progress made and not made by State and local governments. We hope you will pinpoint the individual citizen's job in combatting air pollution.

Finally, we ask you to evolve a program for the future to which we all can subscribe, a charting of the course before us. To be useful, such a chart should assign specific tasks to the groups best qualified to handle them. It should frankly acknowledge obstacles to be overcome and indicate means of surmounting them. It should suggest relative priorities and include some sort of timetable.

This planning is the heart of the assignment. Without it the conference will add up to 3 days of back-patting and wrist-slapping, and little more.

The distinguished and highly competent members of your Steering Committee have wrestled valiantly with the problem of setting up a conference mechanism which will help you to perform this formidable task. The plan embodied in the printed program is the result. We believe it is logical and workable.

Among the first actions of the Steering Committee was to seek the help of eminent citizens representing a wide range of interests in defining the issues. This Inquiries Committee, whose members are listed in your programs, developed the "Questions for Discussion" posed for each of the six discussion groups.

Second, an impressive group of authorities on virtually every aspect of our many-faceted problem were asked to present salient facts. These are the speakers in the plenary sessions and the chairmen, vice chairmen, resource persons, speakers, and discussants who will be heard in the discussion groups tomorrow.

Third, a corps of no less distinguished authorities was enlisted to serve as panel members in each discussion group. Theirs is a key role in framing each group's recommendations for action, which will be presented to the plenary session on Thursday.

I doubt that this much know-how on air pollution has ever before been assembled under one roof. Our confidence in laying such a challenge before you reflects our confidence in the quality of the group.

We have limited the discussion sessions to 1 day, with great reluctance, because we felt the need of a general orientation for all participants. Most of us now know bits and pieces of the air-pollution story—physicians, the medical side; citizens, the nuisance side; engineers, the engineering aspect; and so on. The plenary sessions today attempt to present all sides, in perspective, to everybody. We think that this broad base of information held in common will save time in the long run.

Your discussion group chairmen will explain the mechanics of that operation tomorrow morning. The speakers have been carefully timed so that there may be considerable discussion, and the groups will divide into sub-groups to make the most of the time available.

And now that you know your job and your working conditions, I take it you are prepared to roll up your sleeves and have at it. I think I've covered everything a worker needs to know about a job except the trifling matter of what it pays. As to that, the sky quite literally is the limit, for the more successful your work, the more blue sky and clean air there will be for us and for all who follow us to enjoy. Best wishes and good luck! Come back here at 1:30 this afternoon, prepared for two important symposia that will lay the groundwork for the all-important discussion and policy sessions you will participate in tomorrow.

Afteroon Session—Tuesday, November 18

Chairman
Dr. Leroy E. Burney
Surgeon General, Public Health Service
U.S. Department of Health, Education, and Welfare

SYMPOSIUM—STATUS OF KNOWLEDGE

What's in the Air?

Dr. Herbert C. McKee
Manager, Air Pollution Research
Southwest Research Institute
San Antonio, Tex.

In considering the question "What's in the Air?" it is necessary to admit some lack of knowledge, so that another way to phrase the question is "What Do We Know About What's in the Air?" Some things that are in the air have been around for a long time, and there has been ample opportunity to study the problems they create and learn how to control them. In other cases, however, our knowledge is incomplete because our rapidly changing civilization has recently created new air-pollution problems that are exceedingly complex.

At the beginning, an important distinction should be made between communitywide air-pollution problems and localized problems. While there is a lot of overlapping of the two types, this distinction will help in considering the sources of pollution, the effects on society, and the type of control effort required.

Let's start with the easier one first, the localized pollution problem. As the name implies, this is a pollution problem which exists in a localized area, usually the area immediately downwind from a specific source of pollution. As one moves farther and farther downwind from the source, natural processes in the atmosphere dilute and disperse the offending substance until it cannot be detected. If one moves crosswind, however, and out of the stream of polluted air, one very quickly escapes the pollution.

The variety of pollutants found in localized problems is almost as great as the variety in the human activities which produce them. A few examples will serve to illustrate the great number of substances which may be found:

1. Odors, from sewage disposal plants, paper mills, food processing plants, chemical plants, truck and bus engines (especially diesel), incinerators, and many other sources.

2. Specific chemical substances—which may or may not cause odor, paint blackening, corrosion, or other undesirable manifestations—such as sulfur dioxide, chlorine, hydrogen sulfide, acid mist, solvent vapors, hydrocarbon vapors, etc.

3. Dust of industrial origin, such as cement dust, metallurgical fumes, fertilizer dust.

4. Dust of nonindustrial origin, such as soil particles picked up by wind, salt particles found near a seacoast, road dust (especially near unpaved streets), and the dust arising from construction work, and many other activities.

5. Smoke, of both industrial and nonindustrial origin, from coal-burning furnaces, incinerators, powerplants, junkyard burning, and many other sources.

Let us turn now to the other type of problem, which is more complicated from a technical viewpoint: the communitywide problem. As the name implies, this type of air-pollution problem affects a large area simultaneously, though not necessarily to the same degree, rather than the area immediately downwind from a specific source. Another characteristic is that, in a truly communitywide problem, the atmosphere gets in such a mess that frequently it is impossible to distinguish one pollutant from another, or to tell where each comes from.

This distinction, of course, is not always evident; sometimes there is a transition from one type to another. For example, a diesel bus exhaust may cause a localized odor problem within a radius of a few feet, but the exhaust gases may also contribute to a communitywide problem long after the localized odor problem has disappeared. Weather patterns also have their effect; a smoke plume may affect only the area immediately downwind as long as a steady wind blows. However, if the wind dies down and the smoke accumulates in the air over the city, a communitywide problem may be created from the same source.

Also, let me say right here that the distinction between a localized problem and a communitywide problem is important to the air-pollution research scientist, but may not be nearly as important to the man who is affected personally by the pollution. The person who lives immediatly downwind from a particular source of pollution is not comforted by the fact that his problem does not bother the rest of the community, nor should he be. He is entitled to relief regardless of the extent of the problem that bothers him. However, an understanding of the nature and extent of this problem is necessary to provide the best corrective measures.

One important type of communitywide problem is that which results from widespread use of coal for fuel; this type of problem has been known for several centuries. In fact, clear back in the 12th century, an Englishman was hanged for making too much smoke. Since little was known at that time about proper combustion control, I don't suppose the hanging had much of a deterrent effect; fortunately, in our day and age, we don't have to use such drastic measures. In fact, there is probably less pollution of this type in many American cities now than has been the case for many years, in spite of increases in population and industrial activity. This decrease is due to several factors which will be described by other speakers. Nevertheless, in spite of these accomplishments, many cities still have a communitywide problem as a result of smoke, soot, fly ash, and sulfur dioxide which result from the burning of coal, and a constant effort is required to keep the atmosphere reasonably clean.

One reason why coal smoke is frequently a communitywide air-pollution problem is that it is produced in literally thousands of furnaces and boilers in a typical eastern city. Imagine thousands of chimneys scattered throughout the city, each one more or less like all of its neighbors with respect to the amount and type of smoke emitted. Even if good combustion control is practiced and each chimney only emits a little bit of smoke, the citywide total is enough to produce a real problem which has its effects on society. When we consider what conditions were like in many cities 20 to 30 years ago, it is no wonder that public indignation was strong enough to bring about the corrective action that has taken place.

While any air-pollution problem may affect a large area if conditions are unfavorable, there is one other specific type of communitywide air-pollution problem that should be mentioned. That problem has nothing to do with coal smoke, and so far has occurred to an appreciable degree only on the West Coast, where coal is practically unknown. Los Angeles was the first city to experience this type of problem, and more recently, San Francisco and San Diego. However, except for a few isolated instances which are somewhat doubtful, no cities in other parts of the country have been subjected to this type of pollution.

The Los Angeles-type smog problem is quite different from the coal smoke problem: in many respects, the two are opposites. The former type occurs only when several requirements are met simultaneously:

1. The presence in the atmosphere of organic impurities from automobiles, incinerators, industries, and other sources, with automobiles being a major contributor.
2. The presence of oxides of nitrogen, which are formed in any combustion process and therefore come from powerplant stacks, and again, automobiles.
3. Weather and topographical conditions which allow these pollutants to remain in the atmosphere for extended periods of time without being dispersed.
4. Sunlight, which serves to activate a whole series of chemical reactions.

When these four features coincide, the resulting chemical reactions produce products which have not been completely identified but are radically different from the pollutants which were emitted to the atmosphere in the first place. Whereas the original automobile exhaust and other pollutants do not cause eye irritation by themselves, these reaction products do cause eye irritation which at times can be severe. The original pollutants do not cause damage to vegetation, but after irradiation by sunlight the resulting products do. The original pollutants do not cause any appreciable restriction in visibility, but after these reactions occur in the atmosphere, the mountains which surround the Los Angeles basin disappear into a gray, murky haze. This, then, is the famous Los Angeles smog, ridiculed by the Florida Chamber of Commerce, perhaps, but a real source of irritation to the people who live in it, and with it. Although much has been learned about the nature and causes of this problem, it is a very complex one, and complete understanding of its many facets has so far eluded the competent group of scientists and engineers who are studying it and actively seeking solutions.

So far as the entire Nation is concerned, the important thing about this problem is the warning that it provides about what may happen in other communities. So far, the right combination of circumstances has occurred only on the West Coast to any appreciable degree. However, other cities drive the same kinds of cars; other cities have powerplants, incinerators, buses, and other sources of pollutants; other cities have sunlight; and other cities may at times have unfavorable weather conditions. Therefore, there is a very real possibility that population increases and changes in our method of living may in the future produce an unfavorable combination of circumstances in other cities. If this happens, knowledge now being accumulated in studying the Los Angeles problem will help in providing the proper solutions to any problems that arise in the future.

This, then, is a quick and incomplete answer to the question "What's in the Air?" First, there are many pollutants that affect the immediate area, and that come from many different sources. Second, while many types of communitywide problems may exist, two types are worth special mention: (1) the smoke and soot problem found in many eastern cities, and (2) the quite different type found in cities on the West Coast.

Where Does Air Pollution Come From?

Dr. Leslie A. Chambers

Director of Research

Los Angeles County Air Pollution Control District

Of the several what, where, why, and how questions comprising the subject matter of this conference on air pollution, probably only one can be answered at present with a satisfactory degree of certainty. As a consequence of years of observation, source analysis, and atmospheric sampling by industry, public and private agencies, the points of origin of the primary pollutants going into the atmosphere are identifiable, and their relative contributions readily assessable. Air pollution has many analogies in surface water pollution. One can examine a body of water and determine immediately that it is polluted, but it has proved most difficult to identify the pollutants, to effect economically practicable abatement, or to determine objectively the effects of the polluted waters on user populations. On the other hand, it is easily possible to determine what kinds and amounts of substances are being dumped into the lake or stream by the simple expedient of analyzing contributory effluents from industrial and domestic sources. So it is in the case of our polluted air supplies: the sources are fixable.

There are two general categories of air pollutants with which we must be concerned: (1) those substances which arise directly from industrial, commercial, domestic, transport, or agricultural activity; and (2) those pollutants which do *not* come ready-formed from primary sources, but instead are products of interaction among primary pollutants under the influence of natural forces in the atmosphere.

Air pollution by primary waste products has presented problems in many places and in many ways. Dusts, smoke, fumes, and liquid droplets obscure the sunlight, interfere with aircraft operations, soil buildings and clothing, may be malodorous, and in some cases (e.g., H_2SO_4 mists) have been alleged to be lethal to plants, animals, and man. Gaseous discharges (e.g., sulfur dioxide, carbon monoxide, oxides of nitrogen, hydrogen sulfide) are known to be toxic when present in high enough dosage, in some cases have objectionable odors, and have such a general history of undesirability that their presence in any significant concentration gives rise to public uneasiness and public health concern.

Metallic fumes and dusts (e.g., of lead, vanadium, arsenic, beryllium, and their compounds) when present, usually are unperceived by the public but have raised serious questions among toxicologists as to the probable physiological effects of chronic low-level exposure. Similarly, air-borne compounds of nonmetallic elements, such as fluorine and phosphorous, have not only aroused medical interest, but in at least one case have resulted in a court judgment in favor of a plaintiff alleging impairment of personal health as a result of exposure to fluorides identified with a particular processing plant.

It is obviously not possible to assume that the complex of sources of primary pollutants is the same from one metropolitan area to another; but we can consider the amounts of particular pollutants in terms of some readily usable index which can be specifically applied to analyses of local problems. For example, the amount of sulfur dioxide emitted from the burning of a thousand pounds of fuel oil of a given sulfur content is a pollution unit factorially related to similar activities wherever they may occur. Some of the chief pollutants can thus be packaged in activity units. In each case it is assumed that no control process is in effect.

1. Oxides of sulfur, estimated as SO_2, are emitted from:

   a. Fuel oil combustion at the rate of about 30 pounds per 100 pounds of oil.

   b. Coal burning at the rate of about 40 pounds per ton of coal.

   c. Automobile engines at about 17 pounds per 1,000 gallons of gasoline consumed.

   d. Diesel engines at the rate of about 15 pounds per 1,000 gallons of fuel.

Much smaller quantities of SO_2 are produced from combustion of refuse, possibly 2–8 pounds per ton of burned material. And larger, widely variable quantities are emitted from petroleum desulfurization and other chemical processes where no sulfur recovery system is operative.

2. Oxides of nitrogen, estimated as NO_2, are produced from:

   a. Fuel oil burning—about 13.5 pounds per 1,000 pounds of oil.

   b. Natural gas burning—about 6–9 pounds per 1,000 pounds of gas.

   c. Coal burning—8 pounds per ton of fuel.

   d. Automobile engines—25–75 pounds per 1,000 gallons of gasoline used.

e. Diesel engines—75 pounds per 1,000 gallons of oil burned.
f. Waste incineration—about 4 pounds per ton of mixed refuse.

3. Solids, as dusts, smoke, condensed fumes, etc., result from:

a. Waste incineration at the rate of about 25 pounds per ton burned.

b. Fuel oil combustion at the rate of about 2.5 pounds per 1,000 pounds of oil used.

c. Coal burning—around 200 pounds per ton of fuel.

d. Automobile engines—about 0.3 pounds per 1,000 gallons of gasoline used.

e. Diesel engines—about 100 pounds per 1,000 gallons of oil used.

Substantial amounts of finely divided solid pollutants are also emitted in extremely variable quantities from ferrous and nonferrous metal refining, processing, manufacturing, and finishing and from such activities as cement manufacture, sandblasting, rock crushing, glass and ceramic industries, and many others. The rates of emission in these cases are related not only to raw material and fuel units, but also to the nature of the individual methods used in processing. Indices similar to those above are available but necessarily have limited applicability.

4. Aldehydes, estimated as formaldehyde, are emitted by:

a. Automobile engines at a rate of about 18 pounds per 1,000 gallons of gasoline.

b. Diesel engines at about 30 pounds per 1,000 gallons of oil.

They also are produced in much smaller quantities from a variety of combustion processes in which organic material is incompletely burned, as in the disposal of refuse in incinerators of improper design.

5. Carbon monoxide is produced from gasoline engines in normal operation at the rate of about 3,200 pounds per 1,000 gallons of gasoline. This is the only really significant source of CO, with the possible exception of improper household heating.

6. Organic vapors, often referred to as "hydrocarbons," are emitted as pollutants from:

a. Automobile engines at an average rate of 200–400 pounds per 1,000 gallons of gasoline used.

b. Evaporative losses from automobile carburetors and tanks at a highly variable rate with air temperature—at 100° F. the loss may be 2.5 to 5.0 percent of the gasoline throughput.

c. Evaporation losses from the use of organic paint and lacquer thinners, diluents, solvents, degreasing agents, cleaning compounds, and the like can be assumed to equal the amount used.

d. Evaporation of gasoline during storage, handling, and marketing is estimated at about 100 pounds per 1,000 gallons.

Obviously such a catalogue could be very long and may already have seemed endless. But the items listed probably include most of the major types of pollutants of large air supplies.

In a metropolis like Los Angeles such indices, properly weighted to credit control measures already in use, can be used in conjunction with activity surveys to estimate the amount of pollutants released per day, and the relative contribution of each type of source. For example, as of July 1958, the total of approximately 1,450 tons of hydrocarbons lost to the air on an average day in Los Angeles County is contributed from:

Automobiles	750 tons or 52 percent
Trucks & buses (gasoline)	250 tons or 17 percent
Petroleum production, storage, refining, and marketing	250 tons or 17 percent
Combustion of liquid and gaseous fuels	6 tons or 0.4 percent
Organic solvent uses	180 tons or 12 percent
Miscellaneous minor sources	1.6 percent

Quite evidently more than two-thirds of hydrocarbon pollutants, which play so prominent a role in smog formation, come from the use of gasoline engines in automobiles, trucks, and buses.

Other organic gases, including aldehydes, ketones, acids, and chlorinated compounds, are put into the air at the rate of approximately 205 tons per day, the principal sources being:

Automobiles and trucks	27 tons or 13 percent
Petroleum refining	2 tons or 1 percent
Organic solvent uses	139 tons or 68 percent
Chemical manufacturing	24 tons or 12 percent
Fuel combustion	9 tons or 4 percent
Miscellaneous, minor	4 tons or 2 percent

Direct emissions of this class of pollutants is therefore predominantly from evaporation of solvents, thinners, cleaning agents and the like.

Aerosols, including particulate matter of all types, comprise about 100 tons per day of pollution. This figure, of course, excludes materials of natural origin. The aerosols are produced from:

Automobiles and trucks	34 tons or 34 percent
Petroleum refining	5 tons or 5 percent
Combustion of liquid fuels	30 tons or 30 percent
Combustion of gaseous fuels	8 tons or 8 percent
Metal, mineral, chemical processing	15 tons or 15 percent
Miscellaneous	8 tons or 8 percent

Again it appears that the gasoline engine exhaust tops the list of polluting sources, closely followed by the burning of fuel oil in the production of power.

The inorganic gases indentified as air pollutants in Los Angeles include the oxides of nitrogen, sulfur dioxide, and carbon monoxide together with very small amounts of other organic gases. Of the 700 tons of oxides of nitrogen thus far related to source, 430 tons or 62 percent is produced by gasoline powered automobiles and trucks, and 260 tons or 37 percent from the combustion of liquid and gaseous fuels.

Similarly the automobile exhaust is the dominant source of carbon monoxide. Of the 5,600 tons per day of carbon monoxide, 4,200 tons or 75 percent comes from vehicle exhausts, 1,200 tons or 21 percent from petroleum refining. The remainder, about 4 percent, is emitted from a variety of miscellaneous minor sources.

Sulfur dioxide emissions total about 550 tons per day, of which 48 tons or 9 percent is from gasoline engine exhausts, 50 tons or 9 percent is from refinery effluents, and 400 tons or 73 percent from the burning of fuel oils and gas. The remaining 9 percent is chiefly from sulfur and sulfuric acid manufacturing establishments.

From all this it is evident that the exhausts from automobile engines are by far the largest source of primary air pollutants in Los Angeles

County. About 8,600 tons per day of all types of gases, vapors, and solids are identified as to source with the automobile, supplying 5,770 tons or about two-thirds of the total weight of polluting substances from all sources. In other cities, where less stringent control action has been taken affecting industrial effluents, the proportion of pollutants from the automobile should be smaller, but the absolute amounts per unit of gasoline use cannot be substantially different.

While the amounts of primary pollutants can thus be used effectively to pinpoint urgent control needs in terms of relative quantity, it is most unfortunately true that, in some cases, direct measurement of primary emissions does not account for some of the troublesome substances found in polluted air. Many of the compounds released are able to interact with each other under proper conditions to produce irritating, toxic, or malodorous products not necessarily identifiable with any single type of source. Simple thermal interactions are known to have occurred in some localities to produce odors and irritants.

The secondary products which have as their source a reaction system involving organic vapors and oxides of nitrogen, energized by sunlight, are known to be responsible for the eye irritation, damage to vegetation, and much of the reduced visibility characteristic of smog in Los Angeles. Amounts of secondary pollutants so formed are extremely variable since many of the most troublesome appear to have a very transitory existence.

In the special case of Los Angeles smog it is now reasonably established that the most active hydrocarbon participants in the reaction system are those which are incompletely saturated—commonly termed olefins. From the point of view of one who wishes to trace smog irritants to their primary sources the association with olefins simplifies the task. We have already seen that a major part of the requisite oxides of nitrogen are produced by the use of gasoline in automobile engines. It also is true that the only identified major sources of the reactive olefins are automobile exhausts, and to a lesser degree, evaporation of gasoline.

Therefore, we have arrived once more at the conclusion that automobile exhausts are the source of most of the objectionable qualities of air pollution in Los Angeles, in addition to their major role in total pollution load.

It will be apparent that the use of so much data from Los Angeles—quite aside from its inevitability—is by way of illustrating principles of source finding and pollution control planning. Other areas have employed essentially similar techniques. Determination of the sources of air pollution requires great effort, much of it expensive; but survey methods, source testing, and analytical techniques are available for developing similar control action bases for most situations.

After the sources have been located the real problems arise. What can be done to control them? For Los Angeles this question has become, very pointedly, how can we control pollutants produced from 3 million automobiles?

What Does Air Pollution Do to Humans?

Dr. James P. Dixon
Commissioner of Health
Philadelphia, Pa.

Deeply rooted in our American folkways is, I believe, the notion that those things which offend the senses are to be considered hazardous. This instinct leads to the automatic belief that bad smells are dangerous to our health and that things which taste bad are poisonous. It is also characteristic of our civilization to produce many waste products, and one of the simplest ways to dispose of these waste products is to discharge them into the air. But the sensory knowledge of such air pollutants—whether visible smog or the odor of exhaust from a diesel bus—gives rise to an automatic conclusion: that air pollution as a whole is a hazard to human health. The syllogism, if instinctual, is at least complete.

The step from instinct to scientific proof is, however, not so easily taken. When one makes an effort to analyze the specific hazard that air pollution creates for human health, one is faced with fragmentary information, which in many instances makes it difficult to arrive at a sound, scientifically valid conclusion.

Knowledge in the field is steadily increasing, and there are a few general observations that appear to have validity. It is abundantly clear that, from the experiences in the Belgian Meuse Valley in 1930; in Donora, Pa., in 1948; in London in 1948, 1952, and 1956, under certain meteorological conditions the pollutants in the air arising from home and industrial wastes may build up to lethal concentrations. In Donora, there were 20 deaths attributed to 1 episode, with nonfatal illness affecting half the population. In London during 1952, between 4,000 and 5,000 more people died during 1 week of the episode than would be expected under normal conditions.

Most of the persons who died in these acute episodes were elderly and had histories of cardiac or respiratory ailments. Experienced observers of these acute episodes believe that many similar, but less dramatic, air-pollution incidents may have passed unnoticed, because our community machinery for identifying excess deaths and disabilities is by and large too insensitive to identify smaller disasters. In spite of the fact that the deaths in these acute episodes are clearly linked to the presence of air pollution, the mechanism by which the deaths occur is far less clearly understood. Efforts to link them with specific pollutants have shown that concentration from specific pollutants in the acute episodes did not approach levels considered dangerous for in-plant working conditions in the field of industrial hygiene.

There is clear evidence that certain types of air pollutants, if exposure to them is extended over long periods of time, can cause chronic bronchitis. This is a clinical entity that is well recognized in Great Britain: in a recent appraisal there, the disease ranked third among causes of death and first as a cause of workdays lost due to illness. But here again, the exact mechanism of causation is not clearly understood, although research in this field is continuing.

At the moment, it is believed that the air pollutants cause a basic disability in the respiratory system.

There is certain other evidence of an inferential nature that links air pollution with human illness. It is a well demonstrated fact that the death rates for certain diseases are higher in urban than in nonurban communities. On the list of such diseases, we find arteriosclerotic and other heart conditions and cancer of the stomach and esophagus and of the lungs. Because pollution of the air is more intense in urban areas, it is proper to consider that air pollution may play a role in this increased mortality. But this is a deduction for which there are no data that meet fully the demands of scientific validation. We cannot say, at present, that a cause and effect relationship has been established, for there are obviously many other differences between urban and rural living that should be taken into account.

There is little question—surely no question at all in the minds of people who have been exposed to the Los Angeles smog—that there are irritant agents in this smog which particularly affect the eyes. In various concentrations, such irritants have been proved to be damaging to experimental animals. Evidence of a permanent effect upon humans is, however, still lacking.

Throughout the industrialized world, lung cancer has been showing a striking increase as a cause of death. Much research has been directed to a study of the cause for this increase. Cigarette smoking has been strongly implicated as a contributory cause, but even after correcting mortality rates for lung cancer among urban dwellers for the effects of their smoking habits, the incidence of lung cancer still remains significantly higher in urban than in rural areas. There have been observations indicating that there are a number of pollutants in the air of some communities that can produce cancer in experimental animals. But information of this type does not verify a cause and effect relationship between air pollution and lung cancer, although it does create an insistent demand that the possibility of such a relationship be thoroughly explored.

In summary, then, leaving aside any considerations that the air transports allergens and radioactive particles, it is clear that, under some circumstances, acute air pollution can cause death among older persons and can cause serious illness to others. At least in the instance of chronic bronchitis there is a direct relationship between air pollution and a specific disease. In addition, we know that air pollution can cause temporary disability through eye irritation. But a direct relationship has not yet been demonstrated between air pollution and other diseases that are apparently incident to urban living, although the available evidence supports a strong suspicion that air pollution may play a role, if only a synergistic one, in the development of these diseases, including lung cancer.

The field of public health throughout its entire history has frequently had to operate from generalizations and has developed control measures for diseases even when the specific etiology of a disease was not known. From the point of view of health protection, therefore, our present state of knowledge is sufficient to stimulate a fundamental concern about the relationship of air pollution and health.

The available data demand two courses of action. First, every reasonable effort should be made to reduce the quantity of pollution discharged into our atmosphere. Second, research into the specific health effects of air pollution should be vigorously encouraged so that adequate knowledge, around which we can construct specific control measures, may become available as soon as possible.

The movement of our growing population in this country into ever expanding urban areas makes progress on both fronts urgent. For the world as a whole, we must consider the celebrated "population explosion," which bids fair, by all accounts, to produce geometrical increments of people, industrialization, and fuel usage and to contaminate our atmosphere on a scale never before known to the human race. If gas masks are not to become as common in a hundred years as shoes are today in the civilized world, we should do well to heed our somewhat submerged instincts of self-preservation and remember that—whatever other uses man may devise for it—air is still essentially for breathing.

What Are the Costs to Society?

Dr. Reuben G. Gustavson
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Washington, D.C.

When one questions the total cost in terms of dollars of various pollutants of the atmosphere in bringing about changes in structure or bringing about changes in value, as in corrosion, et cetera, one is immediately struck with the fact that the amount of information available taken as a whole is very, very slight indeed. You feel that you are somewhat in the position of a cowboy who is looking at the Grand Canyon. Somebody asked, "How large is it?" The cowboy said, "I don't know, but it's a hell of a big hole." And that is about the answer, I suppose, that one should give to the cost of air pollution in terms of how much we suffer from it.

I think it is very interesting to examine some of the constituents in the atmosphere on a little finer scale than we have examined them so far. We are all familiar with the fact that the carbon atom exists in the atmosphere in at least 3 forms: carbon 14, which is radioactive and which I am not interested in at the moment; the common form of carbon, carbon with the weight of 12; and carbon with the weight of 15. These last 2 carbons give rise to carbon dioxide, with weights of approximately 44 and 45, and carbon dioxide is, of course, the source material in the atmosphere for plant life. Physical chemistry teaches us that the rate of motion or velocity of molecules varies inversely as the square root of their molecular weights.

Now that is a pretty learned discourse, I hope, for everybody, but what comes out of it, of course, is that carbon 12 or carbon dioxide 44 will obviously find its way into plants at a greater rate than carbon 13 with the weight of 45. Consequently, in the distant past, when plants were growing very prolifically, we were having a ratio of carbon 12 to carbon 13 in the plant structures greater than it is in the atmosphere. This ratio is tabulated for us in the tree rings that cover a large number of years. It is interesting to note that if you study this ratio of carbon 12 to 13 and tree rings against time, while that ratio remains very constant apparently for a long time, at about 1825, or in that area, we find that there is a change. At this time we had the great industrial revolution. That revolution involved the burning of fossil fuels and this meant, of course, the liberation of quantities of carbon 12 over what we had had in the atmosphere. So we have a natural calendar of tree rings which tell us that at this particular time man began to have an influence on the composition of the atmosphere.

Now surely there isn't any hazard in being associated, as far as I know, with a slight change in the ratio of carbon 12 to carbon 13 in the atmosphere, but I think it is interesting to indicate that the industrial revolution began to change man's environment. The combustion of these fossil fuels, as has been said by previous speakers, poured into the atmosphere carbon dioxide, which is acid in character and which plays an essential part in bringing about the solution of rock materials for the soil and thus feeding our plants. We also began to pour acid fumes into the atmosphere, such as sulfur dioxide, sulfuric acid, oxides of nitrogen, becoming nitric acid, and so on. Carbonic acid, of course, acts as a corrosion influence because of its acidity, but it is interesting that the salts that are formed from carbon dioxide are relatively the insoluble ones, so that there is a limit to their action, with the result that the green roofs which are so widely used today are generally of basic carbonate and corrosion ends when these insoluble salts prevail. But salts that are formed with nitric acid and sulfuric acid are soluble and are washed off with the rain and hence we find, of course, that these acids exert a corrosion effect which is very real indeed, since there is no protective coating formed.

Various estimates have been made as to just what air pollution's cost to society is, and perhaps a figure which is as good as any is the figure of $7.5 billion a year.

I think it is also interesting to note that if you examine human activity for long periods of time, a pattern is established and it remains fairly constant. Then one finds people who begin to question the pattern and the rumblings begin to occur and these rumblings increase in intensity until finally we arrive at revolution. Revolution is always followed by a period of uncertainty and then the period of uncertainty is followed by a period of insight.

We can take the pattern, for example, of human slavery as a subject that we might refer to. This pattern is almost as old as man, but some time around the 1800's man began to question this in our country and it resulted in revolution in the form of the Civil War in the 1860's, followed by a great period of uncertainty, which perhaps is still with us, but is now gradually beginning to move into a period of insight.

It seems to me this has also been the situation with respect to air pollutants. We have tolerated the situation over long periods of time and then some of these disasters which have been described, which are described so frequently, such as the London smog and others in which death occur, give rise to what one might speak of as a revolution in our thinking, a strong demand that something be done. But here again the revolution is followed by uncertainty and this period is one in which we are not quite sure what to do about it. This has to be the period then of gathering information and this is the period which it seems to me we are largely in today. It is the beginning of the period of insight, after the revolution period and the uncertainty period. As a previous speaker said, the early method of stopping pollution of the atmosphere by smoke was to hang the individual concerned, but he admitted that this was rather drastic, as is characteristic of most revolutionary activities.

Today, we face the problem of knowing what in the atmosphere gives rise to pollution. We know pretty well where it came from. We have made some very rough estimates of the cost, very rough indeed. When you try to get figures, for example, on the total or the average cost, you get figures which 10 years ago were stated to be in the neighborhood of $10 per individual, whereas studies made recently indicate that this should be closer to $65. But either one is a tremendous amount of money when you multiply it by the population.

Frequently a figure is given that perhaps air pollution costs in the neighborhood of $4 billion a year. But this doesn't begin to take into consideration many of the costs which are secondary costs. If you travel around Washington, or if you did last week, let me say, especially in the suburbs, where the intelligent people live, you would find tremendous bonfires going where people were burning leaves. Now this is one cheap way to give dad some exercise, to pollute the atmosphere, and to get rid of the leaves, but if you choose a better way, hauling them away and dumping them or doing whatever else may be done with leaves that are hauled away, you still have a great cost in terms of picking up the leaves and carrying them away.

Industry has recognized its responsibility in a great many instances. It has taken care to introduce various forms of control. Today, however, we are entering into a field of dealing with pollutants that do not lend themselves readily to this kind of treatment; today we are dealing with tiny molecules rather than just visible aggravants; we are dealing with small molecules and we are dealing with the complex chemical composition of these pollutants in the atmosphere. For one thing, it would seem to me that insight, which I am talking about in this conference, insight after a period of uncertainty, would demand that we should make the most careful kind of study of the automobile for one of the major contributors to air pollution has been, as was indicated by one of our speakers, the automobile.

We find the statement made, for example, that the amount of unsaturated hydrocarbon in the exhaust is in part a function of the unsaturized hydrocarbons in the gasoline. This has been established for a certainty. But to what extent are unsaturates formed either from saturated compounds in the combustion chamber of the automobile or in the internal combustion engine itself? In what way do the number of pollutants vary with the operation of the automobile? What can be done to destroy the pollutants before they get into the atmosphere?

One naturally thinks of some kind of catalyst such as palladium oxide or a combination of iron and palladium oxide to control the burning of these lethal gases.

What about the temperatures that will be developed as a result of combustion of these non-burned fuels? What kind of metallurgy is necessary for mufflers into which such burned gases would pass? What about the chemical dynamics in the inside of the cylinder itself?

I was talking with one of the directors of research of one of our great automobile organizations the other day and I asked him: "What is really known about the temperatures, about the chemical dynamics of the combustion chamber in the automobile cylinder?" He said, "Well, something, of course, but not nearly enough. We do not know the various reactions that take place; we do not know the order in which they take place; we do not know the dependence that one has upon the other." Until this basic research is carried out, the possibility of changing the character of the effluents is not very great.

Well, what does all this mean? It seems to me it means that man has to recognize that he has been characterized over the ages as an animal who pollutes his nest as few animals do. He pollutes the soil for his plant life; he pollutes the water which he drinks and uses for industry; he pollutes the air that he breathes. Since these living activities are universal, surely it means that Government and private industry must cooperate in spending large sums of money in order to get basic answers to some of the very fundamental problems of pollution of the atmosphere that we have.

Now sometimes it is said that Government operations are antagonistic to private industry and private industry would just as soon not cooperate with Government. That is not as true as some people would have you believe, but even if it is true, then since we are all in this together, I would suggest that you read Schopenhauer, who said, "In the wintertime even the porcupines huddle together for warmth," so it would seem to me with this increasing pollution problem that the porcupines of the Government and the porcupines of private industry, the Public Health Service, the Bureau of Mines, the automobile companies, et cetera, should put their heads together. Then, following a period of uncertainty we may have insight into the solution of a problem whose costs are not too definitely known, but whose costs are indeed large.

What Can Be Done About Air Pollution?

Charles W. Gruber
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The purpose of this paper is to present some general concepts of what can be done to improve our oudoor air. The four previous speakers have presented the gloomy or smoggy side and it becomes my purpose to show that there are a few rays of sunshine breaking through the inversion layer.

What do we mean by "what can be done?" Does this mean what can easily or readily be done? Does it mean what is it possible to do? Does it mean what needs to be done? We will consider the question by looking into what is being done and then examine what needs to be done. All of this is in 10 minutes.

For further orientation let us consider:

1. What can the community (the recipients of air pollution) do?

2. What can the contributors to air pollution (those responsible for sources) do?

What Can the Community Do?

The community can establish an air-pollution control program geared in breadth and depth to its particular needs. This, of course, must be done to conform with any State statutes regulating air pollution and with due regard for the local jurisdictional authority. Air pollution regulations seek to limit the discharge of objectional substances and in some cases specify how equipment is to be installed and provide for licenses to operate or registration of sources.

Such regulatory programs are not "patently" citizens against industry. It has long been recognized that the private citizen shares with industry the responsibility for contamination of his outdoor air. His home heating furnace, the car he drives, the waste he disposes of, and the leaves he likes to burn, though individually small, collectively are an important contribution to community air pollution.

So in many communities, the clamor for action has resulted in regulation over the citizen himself. Notable examples of such measures can be found in the so-called fuel restrictive ordinances of Cincinnati, St. Louis, Pittsburgh, and Allegheny County, Pa., which restrict the type of solid fuel that can be burned in hand-fired furnaces. This action regulates thousands of individual citizens and has produced striking results. Other communities have boldly changed the household waste disposal habits of millions of its people in their drive toward meeting their objective.

Having adopted an air-pollution control ordinance, the community can and should evaluate the results by the establishment of an air-monitoring program. If we make the assumption that when the individual sources of pollution that can be seen, felt, or smelled are brought under control, the job will be done, then we are closing our eyes to the facts. In Cincinnati, we are told by observers that we have a good regulatory program against the visible sources of air pollution. Yet, when you look at what collects on a high volume filter paper, you will make up your mind right quick that the job is not yet done.

Evaluation means measuring the effects of communitywide pollution. This is something which at present is not readily available to the average American community.

During the preparation of this paper, a question was posed to a dozen seasoned control officials. "What do you need to assist you in conducting a more effective control program in your community?"

Analysis of the replies indicates:

1. The need for rational emission limitations based on a sound evaluation of the cause and effect relationships, considering both sociologic and public health aspects of air pollution.
2. The needs in the field of measurements for:
   - (a) More simplified measuring techniques to determine community progress.
   - (b) Defining and limiting outdoor odors.
   - (c) More simplified methods of evaluating peak stack emission of particulates.

(d) The development of indicators for gaseous contaminants.

3. The need for considering emission rates and concentration concepts in land use planning and zoning regulations.

4. The need for better technical information and reference data on the effectiveness of control equipment.

In view of the strong emphasis on the need for measurement, and evaluation of cause and effect relationships, would it not be better to seek a more fundamental set of values by which to judge the quality of our outdoor air? Should we not establish criteria for undesirable substances in terms of concentrations or effects which would qualify the atmosphere as acceptable or unacceptable from the standpoint of comfort and cleanliness, or safe and unsafe from the standpoint of the health of the people of the community?

What Can Those Who Control Sources Do?

There are four avenues by which to approach the job of reducing the effect of air pollution sources.

1. Select an advantageous site.
2. Change to an advantageous process or equipment.
3. Use more suitable materials (including fuels).
4. Apply control equipment or control measures.

In seeking the solution to any air-pollution problem, all four methods should be examined either singly or in combination. Each has its own opportunity for application in both citizen and industrial pollution control.

For example—in pursuing the most elusive question before us today, what can be done to reduce the effects of automotive engine exhaust, three of the four avenues have possibilities. (It is obvious the site cannot be changed.)

1. The engine or its components can be changed.
2. The fuel might be changed.
3. Control equipment can be applied.

In this particular problem, the application of control equipment appears to be the most likely solution.

By and large, the most frequent selection in control measures is to apply control equipment. This trend has led to an active development in control equipment. Today the control equipment business has reached sizable proportion, with annual sales reaching the hundreds of millions of dollars. This appears to be a realistic estimate when we consider that one utility company, the Cincinnati Gas & Electric Co., invested 2½ percent of the capital cost of Beckjord Generating Station, just recently completed, in control equipment. This amounted to over $2 million and the station is located outside of any air-pollution control jurisdiction.

In other fields, notably chemicals and fertilizer, processes have recently been installed in the Cincinnati area where the investment in control equipment has reached 20 percent of the capital cost.

Now as to the control equipment itself. It can be stated that there is really no fundamental limit to the cleaning efficiencies attainable.

Singly and in combination, collectors are capable of up to 99.99 percent removal. It is entirely possible and often practical to discharge the process air with less contamination than when it entered the process. When this is done, the process surely merits the "good neighbor seal of approval." If we would stop to realize that someone else will use this same precious commodity, the outdoor air, a second time and perhaps a third or fourth time, we would be more inclined when we "borrow" it to return it in first class condition and not promiscuously to "use it up."

We find that there is a collector or control measure for *nearly* every situation. The sessions tomorrow will discuss all the specifics of control equipment. By again referring to the "poll" of control officials we can draw up some of our immediate "needs" for control measures.

1. The most "popular" in this category is the need for an effective device capable of removing the necessary quantity of the unburned or partially burned hydrocarbons contained in auto engine exhaust.
2. The development of high temperature gas filtration media which are less costly than the present available equipment.
3. Better means of disposing of city demolition debris.
4. A more economical solution to the emission from the small foundry.
5. A practical means of controlling the discharges from coke ovens.
6. A better understanding of the needs and methods to control combustion ash discharge from heavy oil-fired equipment.

The long range needs were cited as:

1. A practical method of reducing the SO_2 in the discharge from combustion processes.
2. Pursue intensively the role played by oxides of nitrogen in the smog reaction and look ahead toward the day when it may be found necessary to limit the emission from the largest source.

In summary, we have drawn attention in a very general way to what the community can do, what those who control air-pollution sources can do, and in essence what the researchers need to do to provide some of the answers we all need in our continuing effort to provide our communities with cleaner, healthier outdoor air.

SYMPOSIUM—ACCOMPLISHMENTS

Accomplishments in Air Pollution Control by the Control Agencies

Raymond R. Tucker

Mayor, City of St. Louis, Mo.

The first antismoke legislation passed by our American cities made no provision for enforcement other than the regular police forces.

Subsequent ordinances, recognizing this lack, provided for one or more "smoke inspectors" usually reporting to the health commissioner or building commissioner.

By the turn of the century, most cities were realizing the need for more adequate enforcement facilities and were establishing bureaus for this purpose. Most of these agencies have continued with a more or less continuous history to the present time.

During the last decade-and-a-half the duties of many of them have been enlarged to include the control of all kinds of air pollution in addition to smoke.

These agencies range in size from one employee to several hundred. The staffs of most of them consist of one or more technical men with sufficient field inspectors to cover the area. Some, particularly those of Los Angeles County and New York City, have laboratory and research facilities. Their annual budgets run from a few thousand dollars to over three and one-half million.

This paper will attempt to outline briefly some of the contributions these agencies have made and are making today to the fight for cleaner air.

The Elimination of Atmospheric Smoke

As American industry, powered by steam engines, reached its ultimate growth in the late 19th and early 20th centuries, the people who lived nearby began to be increasingly annoyed by the black smoke which belched from the factory chimneys.

For many years this was regarded as one of the nuisances which had to be endured if the land was to enjoy prosperity. Smoke pouring from every smokestack, and trailing far back over the many freight trains puffing cross-country, was proof positive that "business was good."

When the people did suspect that perhaps this was not a necessary nuisance—that "soft" coal could be burned without objectionable smoke—they reacted in typical American fashion: they demanded their city governments do something about it.

The result of their agitation was the formation, in several cities in the eastern half of the United States, of the first municipal smoke regulation agencies. For the most part, understaffed and underpaid, hampered on the one hand by blase and timid political officials, on the other by indifferent if not openly hostile management, they did not make impressive headway in ridding the skies of smoke.

But they did make important contributions which were later put to good use. They also kept alive the "clean air" spirit and became springboards for the more mature and effective programs which were to follow.

They were not slow to recognize the fact that, while they were struggling with the smoking chimneys at hand, they must insure that the number of these did not increase with each new installation.

Still to be found are smoke control office drawings showing proper construction of downdraft boiler settings for smokeless operation, and for other burning equipment of the day. As stokers began to appear in increasing numbers, instructions for their installation and use were published by the control agencies.

This activity, followed today, and extended now to include burners for all the modern fuels, and even for the destruction of refuse, is one of the more important contributions to the practice of air-pollution control.

For it the control offices can take full credit. Regulations drawn up and published by them, and enforced by them through field inspections, have resulted in hundreds of thousands, if not millions, of burning equipment installations giving complete customer satisfaction, operating efficiently, and above all, without smoke.

The smoking chimneys of those cities where such regulations have not been in effect, where competition rather than engineering has determined the design of burner settings, prove their great worth.

Out of a municipal smoke regulation office (the one of which the author happened to be the head) came also a second major contribution toward the elimination of city smoke.

This was the enactment into law of the principle of fitting the fuel to the equipment and the equipment to the fuel. It was done, of course, by prohibiting the firing by hand of inherently smoky fuels and requiring the use of automatic fuel burning equipment when such fuels were to be used.[1]

Put into effect and rigidly enforced by a trained staff, the almost immediate transformation it wrought in the city's atmosphere was such as to attract worldwide notice. Its success put new life into the smoke abatement movement, then at low ebb, and it became the basis for nearly all subsequent air-pollution control programs in localities where smoke was a major problem.

This legislation contained an additional innovation—it was the first to require washing of certain sizes of coal for the city's market. Being a high-sulfur coal, washing removed a large proportion of the sulfur.

The effect on the city's atmosphere, while it did not receive the publicity accorded the reduction of smoke, was none the less welcome to the residents. The good people who, for years, had smelled and tasted sulfur all winter long were no longer aware of its presence in the atmosphere.

Today a large and ever increasing proportion of the Nation's long-haul coal is washed. Asked what has brought this about, the coal man will tell you it was made necessary because mechanical mining produced a dirtier product and competition required that it be cleaned for the market.

On second thought he will add that the demand for cleaner air has also been a compelling factor, prodding the coal producer on to do what he could to prevent the air's pollution by his product.

It was inevitable that the fly ash problem should follow on the heels of the smoke problem. The increasing use of pulverized coal and, later, of spreader stokers was bound to bring forth a flood of complaints, not only from those who lived near the plants, but from entire communities. These complaints, naturally, were directed to the smoke control offices.

Industrial public relations were, for the most part, not as highly regarded in those days as they are today. The first collectors installed for the sole purpose of preventing fly ash nuisances were purchased very grudgingly and often only after the threat of legal action or actual prosecution. (In all fairness it should be added that this was not always the case.)

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[1] St. Louis, Mo. Ordinance 41804—April 8, 1940.

Early regulations limiting fly ash discharge were somewhat liberal because of the relatively low efficiency of the collectors of that day. Today collector efficiencies are approaching 100 percent and no plant to burn powdered coal would be designed without fly ash collectors except for a most remote location. The control agencies cannot claim full credit for these changes, but they remember that they were making fly ash an issue when no plant operator wanted to talk about it.

Incidentally, fly ash is getting into the "big business" class. As an additive to poured concrete, to concrete blocks, to road surfacing compounds, it is finding an ever-expanding market. The once despised nuisance may yet wind up as a profitmaking byproduct.

It can be truthfully said that the battle against the city smoke palls has been won. The control agencies can congratulate themselves on this; it is a battle they fought, almost alone, for many years.

Ways and means to prevent smoking of any size fuel-burning plant, from the smallest to the largest, are now at hand, have been demonstrated to be effective time and again, and have been ruled legal by high courts. If there be a locality still suffering from old-fashioned smoke palls, it is because it has disregarded these well proven tools.

Control of Nuisances Resulting From Disposal of Waste

Several factors have combined to make the disposal of waste materials—industrial, commercial, and household—of increasing importance. The first means to this end which comes to mind is to burn them, and this practice became so prevalent years ago that it demanded the attention of the control offices.

Soon after the Second World War, gas-fired domestic incinerators began to appear on the market in growing numbers. These operated on two principles.

One type, with a low burner input, gradually dried the charge and consumed it. A second type was designed to ignite and burn the charge using a higher input burner. Both were successful in disposing of waste but, as the numbers in use grew, the emissions from their chimneys became more and more of a nuisance.

Under pressure from the control agencies, the manufacturers have now redesigned and improved their appliances. The changes are due, largely, to research projects at the American Gas Association laboratory and Battelle Memorial Institute.

Now appearing on the market are domestic incinerators with higher gas inputs to increase combustion temperatures and afterburners to completely consume flue gases. The new products substantially, if not completely, eliminate the objections directed to their predecessors.

Some control offices, as previously mentioned, have published regulations for the erection and installation of incinerators of all sizes. These are particularly valuable when applied to larger-size destructors for industrial or commercial use, many of which, not too many years ago, were built in the shape of a single chamber fire-brick box, with a grate across its middle and a chimney on top.

The flue-fed incinerator has been the object of much attention on the part of the control agencies of several cities. In New York City, for example, where the nuisance created by these devices was of major magnitude, quite elaborate means have been employed for reducing emissions from them. In at least one city their use has been banned by ordinance.

Of course a considerable portion of our waste material never saw the inside of an incinerator. Much of it was burned in open fires. St. Louis had its ash pits, Los Angeles its backyard trash burners.

By eliminating these the control agencies have aided the sanitary situations in several localities. Where individual disposal was abolished, trash collection programs became mandatory. This is another instance in which efforts toward improving atmospheric conditions have resulted in benefits along other lines.

Closely related to the problem of trash disposal is that of removing combustibles from scrap metal. This becomes of major importance in the case of scrap auto bodies.

One of the foremost sources of scrap steel, they must be freed of wood, rubber, fabric, in short, of all combustible materials to be of highest value. The common practice has been, and still is in most yards, to pile them up, soak the fabric with gasoline, and set fire to them. The resulting nuisances have been the causes of many complaints to the enforcement offices.

In some cities experimental incinerators have been built by individual scrap yards with varying degrees of success. Pressure by control agencies in all parts of the country led to a research project sponsored last year (1957) at Battelle Memorial Institute by the Institute of Scrap Iron and Steel, Inc.

This led to design of a moderate-cost incinerator to burn smokelessly 10 to 15 bodies a day. The estimated cost of about $7,000 seems to put it in the range of most smaller yards and it can be enlarged to increase its output. It appears that this most vexing air-pollution problem may have found a solution.

Industrial Air Pollution Problems

The sources of air pollutants in the manufacturing industries are, of course, many and varied. They cannot be attacked on a wide front since each presents its individual problem. And since each requires expert knowledge of the processes involved the solutions will generally be worked out by the industries themselves, the control agencies supplying the incentives.

The bulk of what has been accomplished along these lines has taken place within the past decade as emphasis has shifted from smoke to other atmospheric pollutants. In that relatively short time surprising progress has been made.

Probably every community with a control program in action has faced a local air-pollution problem and solved it. To mention a few: extinguishing the refuse-pile fires at the coal mines around Pittsburgh and laying down new piles in a way that prevents spontaneous combustion; development of a means for eliminating smoke and solids discharge from apartment-house incinerators in New York City; working out a plan for the smokeless operation of the kilns of

St. Louis' large ceramic industry in the days before natural gas was available to them; elimination of hydrogen sulfide burning at the refineries of Los Angeles County by building a plant to produce elemental sulfur from the waste gas.

The important thing is that these remedies have been worked out and that the knowledge so gained is available to all other communities. In the words of the director of the Los Angeles County Control District, clean air for many of our urban areas can now be "bought off the shelf" by applying technical knowledge acquired during the past decade.

Odors

Odors, often among the most offensive of the atmospheric pollutants, arise from industry, from processes of nature, and from activities of everyday living. Perhaps less is known about them than about any other air pollutant, but considerable work has been done in the field of odor control.

In reviewing the accomplishments of the control agencies, it is interesting to note that two, those of Cincinnati and Niagara Falls, have been especially active in outdoor odor control. The Cincinnati office developed a method of reporting odor levels and characteristics which, since some refining in a private laboratory, has become an American Society for Testing Materials Standard for Odor Determination.

The Need for Control Agencies

One service which falls naturally to the control agency, which is becoming more and more important as air-pollution control work is intensified, is that of collecting, compiling, and disseminating statistics and information regarding atmospheric conditions in the local area.

From the earliest days of their existence they have been attempting to do this (possibly prompted at first by the necessity to have figures denoting progress in order to justify their existence).

As knowledge of the subject increased, methods improved, and the last several years have seen the development of instruments to automatically record quantitatively nearly every desired atmospheric constituent. Today such figures are news. A recent survey [2] made among the country's full-time enforcement agencies showed that half of them were employing recording instruments of some kind in the collecting of data, and only three offices assembled no such figures at all.

As long as we have air-pollution control, we will need the governmental control agencies. Even if they gather no statistics they will be our enforcement officers, upholding the standards set up for all new installations of equipment which might be a source of air pollutants, and cracking down on those whose emissions to the atmosphere violate the established standards of performance. No program, now matter how brilliantly conceived, can be better than its enforcement.

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[2] J. H. Carter, Measurement of Progress in Air Pollution Control, Proc. 51st Annual Meeting A.P.C.A., 1958.

Accomplishments in Air Pollution Control by the Steel Industry

Max D. Howell

Executive Vice President, American Iron and Steel Institute
New York City

We in the steel industry welcome this opportunity for me to come here today to discuss briefly with this National Conference on Air Pollution some of the recent accomplishments of the steel industry in enhancing the art of air pollution abatement, and in reducing the pollution of the atmosphere resulting from some of our operations.

Since time will not permit an exhaustive discussion I shall outline briefly what American Iron and Steel Institute has done on behalf of the steel industry, and outline some of the things that individual companies have done for themselves.

Because many of our protective devices have been installed as integral parts of new equipment and many others have been added to existing equipment, it is not possible to give you an accurate figure of expenditures in this field.

An idea of its magnitude may be had from the fact that two of our companies have spent more than $84 million on air cleaning equipment since 1950.

American Iron and Steel Institute has been actively interested in air pollution abatement since 1950. In that year we signed our first contract with the Industrial Hygiene Foundation of America at Mellon Institute to pursue work in that field. The interest of individual companies goes back, of course, many years further than that.

In 1950, conditions in the field were less than ideal. It was difficult even to define the problem to be solved inasmuch as there had not then been developed simple, effective, and inexpensive instruments which could take a sample which was truly representative of either the ambient atmosphere or of stack gases. Therefore, the Mellon group set out to develop instruments and techniques which would be useful in these fields.

Among the instruments developed was an automatic smoke filter which samples the atmosphere for successive short-time periods, measured in hours, and permits the tracing of the variations in smoke intensity, largely due to weather, making possible comparisons between different districts, and between different seasons. The production and sale of this instrument was undertaken by a commercial instrument maker, and I am sure many of you in the audience have used this instrument and found it helpful in your sampling programs. A hydrogen sulfide sampler which continuously monitors the atmosphere and an instrument for measuring hourly dust-fall rates with a high degree of precision, were also developed. Coupled with the development of the instrument was the development of the techniques required for utilization of these instruments.

At the same time a development program on stack sampling was carried out which included the evaluation of techniques for measuring particle size distribution of the recovered dust. Because of the possible error in measuring particle size distribution of dust after its removal from the gas stream (agglomeration or dispersion of the particles during measurement), a great deal of research work was undertaken on separating the various particle size fractions of dust while it was still in the original gas stream. Unfortunately, a completely satisfactory system was never developed.

A training school was set up to which the various members of the American Iron and Steel Institute sent men to be trained in the techniques used in air-pollution studies. The course ran for 3 months and comprised formal and informal seminars, literature assignments, plant visits, and laboratory work.

In addition to the aforementioned studies, existing cleaning equipment was critically examined with a view towards classifying it into groups of optimum usefulness. No single device was found which could do all the things necessary to meet air cleanliness requirements.

Therefore, the members of our Committee on General Research were persuaded that an attempt should be made to develop a new type of filter device which, hopefully, would fit into the metallurgical stack gas cleaning program somewhat better than did the conventional cleaning devices. To implement this idea a research project was set up at the Harvard School of Public Health. Studies of various filtering devices were made and a new type of continuous self-forming filter made from slag wool revolving in a horizontal plane was devised.

The filter combines in one device the versatility of a scrubbing or washing device for gases, with the high efficiency of a fiber filter for particulate matter. Mineral wools withstand temperatures greater than 1,000° F. which permit their use on flue gases and furnace effluents. The wools being used are made from blast furnace slag, are reusable many times, and exhibit efficiencies greater than 90 percent.

Three pilot filters have been built and tested at an eastern steel mill, each an improvement on the other. A fourth, and hopefully final, filter plant is now being designed.

We are currently pursuing research at Battelle Memorial Institute seeking means to control particulate emissions from Bessemer converters. We are attacking at the source in an endeavor to prevent the formation of fumes in the metal bath. This attack is necessary because no mechanical device which will eliminate these fumes to the desired degree has been developed anywhere in the world.

For the past year we have sponsored pathological research at the Industrial Hygiene Foundation of America at Mellon Institute. The results of that work, which will be made public by Dr. Paul Gross before the spring meeting of the American Industrial Hygiene Association, have been most enlightening and of such nature as to be pleasantly reassuring to the public at large.

Over the years, the steel industry has been searching out the most obvious air pollutants and correcting them, wherever possible. Many steam boilers were converted from coal to gas and many process heating furnaces were converted from coal fired to natural gas fired or to electric heating. Steam locomotives, steam cranes, and even steam river boats are being gradually abandoned in favor of diesel engines.

It is of interest to this group that the raw material used in largest quantity by the steel industry is air. During the production of 100 million tons of steel from raw materials to finished products, there will be used at steel plants more than 1 billion tons of air which must, of course, be returned to the atmosphere. In many cases it contains both coarse and fine particles.

These particles originate in the mechanical and chemical reactions of hot gases in the in-process materials inside sinter machines, coke ovens, blast furnaces, melting furnaces, converters, or soaking pits, or on scarfing beds; from the chemical reactions and agitation in the molten bath; and from the combustion of fuels. They are not the result of inefficient or sloppy practices. They are inherent in steel manufacturing processes.

Coke ovens have been and are sources of smoke. Protective devices are being installed as rapidly as possible. One deterrent, however, is the age of some of the equipment. Normally, a battery of coke ovens will have a life of some 30 years and the original designs of several years back do not lend themselves to the addition of efficient protective equipment. All coke ovens which have been built in recent years have had built-in equipment to shorten the time of charging, vacuum-charging equipment to ensure minimum emissions during charging, equalizer mains, and self-sealing doors, all of which have had a noticeably good effect.

One company added self-sealing doors to 180 ovens at a cost of $954,000.

As you might imagine, not all of our efforts have been crowned with success. Several companies have added double gas collector mains to new batteries at a cost of $350,000 per battery, with the hope of minimizing air pollution from coke ovens. This approach has proved to be of doubtful value in the alleviation of pollution.

Blast furnaces produce about 150,000 cu. ft. of gas per ton of iron. Many protective devices have been added to blast furnaces in recent years, and in many cases the cleaned, burned gases emit less than 10 pounds of dust per ton to the atmosphere, well within any normal standard of cleanliness.

Occasionally a blast furnace "slips," that is, its burden shifts downward rapidly and thus opens safety bleeder valves to relieve pressure. When this happens, some dust is ejected into the atmosphere. There is no known method to completely eliminate blast furnace "slips," and the gases from a violent "slip" must be released to the atmosphere, or the top will blow off the furnace. However, the number of "slips" has been substantially reduced through the years by improved ore burdens and by improved practices. In many cases bleeders have been installed on the clean gas side of the blast furnace gas cleaning system. Then when a "slip" occurs, dirty gas will be prevented from going to the atmosphere, provided the "slip" is not a major one.

The dust-catching equipment on blast furnaces is quite varied and almost all types are employed, running from venturi and orifice scrubbers through tower washers to electrostatic precipitators. It is all costly. One of our companies equipped four blast furnaces with electrostatic precipitators at a cost of $3 million, then added a gas bleeder at an additional cost of $200,000. Another company equipped its two furnaces for high top pressure, a cleaning device in itself when it is applicable to the particular operation, and installed venturi type wet washers, all at a cost of $700,000.

For comparison and evaluation purposes, a third company varied its cleaning lines. Two furnaces were equipped with dry dust-catchers and electrostatic precipitators. To one line was added a wet washer, to the other a venturi scrubber. The total installation cost was $1,800,000. Soon comparative efficiency data will be available for both cleaning lines.

The effluent from open hearth furnaces represents the industry's largest and most persistent problem. As of January 1 of this year there were 926 open hearth furnaces in the United States, with a capacity to produce more than 122 million net tons of steel, or 88 percent of the industry's steelmaking capacity. Since about half of the dust coming from an open hearth is less than a micron in size, mechanical cleaners are not effective, and it would appear from the results of research to date that precipitators, high energy scrubbers, or filters may be required. Four installations are presently operating on open hearth gas cleaning. They employ waste-heat boilers to reduce the gas temperature and electrostatic precipitators to do the cleaning. The initial installation has proved to be exceptionally trouble-free. However, the three subsequent installations, which were on large hot-metal furnaces, have shown very serious operating problems. In each case, the contractor has, by suitable modification, been able to solve these problems. This illustrates the fact that precipitation of open hearth dust is still more of an art than a science. An additional problem appears in the older open hearth plants, where space requirements for the installation may be a major problem.

On many furnaces automatic combustion controls have been installed to control the fuel-to-air ratio, which results in more complete combustion and consequently less effluent.

One company has equipped nine open hearth furnaces with electrostatic precipitators since 1954 at a cost of $5.5 million. Another company which has added automatic fuel and combustion control equipment to 11 open hearth furnaces has spent for it more than $7 million since 1950.

The new basic oxygen steelmaking process has required special equipment to suppress effluent. This has been done very successfully by the use of spark traps and wet washers (such as disintegration and high-energy scrubbers) followed by moisture eliminators. The cost of this equipment installed in a new steelmaking plant of approximately 1 million tons capacity was $2.2 million. Other companies are using dry electrostatic precipitators for cleaning the gases.

Electric furnaces have had their share of attention. The most popular type of air-cleaning device in use on electric furnaces is the "bag-type," in effect, a giant vacuum cleaner. Dusts from an electric furnace carry all smoke from the melting operation to a four-room building known as a "bag-house." In 1 new installation there are 195 dacron bags, 15 feet long and 6 inches in diameter in each room. These bags collect the dust from the air which passes through them. Once an hour one room at a time is shut down automatically, the bags are shaken vigorously and the dust from them falls into a collecting hopper where it is mixed with water to form sludge which is settled and dumped. This installation, which can also be used on the basic oxygen process, has a very high efficiency, and costs $125,000.

Many other operational units of the steel industry have been safeguarded at substantial cost. Boilerhouses have been equipped with electrostatic precipitators and raw material preparation has reduced dust materially. Water sprays have been installed on car dumpers at ore and coal handling facilities. Sinter plants have been protected by cyclone cleaners, and water sprays on cooling tables. Scrubbers have been installed on coal pulverizers and coal washers. Soaking pits have been protected by waste gas controls. Scarfing beds and scarfing machines have been equipped with cyclone dust catchers, electrostatic precipitators, and wet washers. To protect one such machine costs $100,000.

The foregoing record only sketches the outlines of what has been done. Many old problems remain and new ones will arise. The steel industry will attempt to solve them all as speedily as may be possible. There is much research and development in progress. We hope that we shall be permitted to work out the solutions to our problems without being hampered by restrictive legislation, which can have little grounding in reality until the state of the abatement art is more advanced than it is today.

Accomplishments in Air Pollution Control by the Automobile Industry

Harry A. Williams
Managing Director
Automobile Manufacturers Association, Detroit, Mich.

As an opening thought, it must have occurred to many that the Surgeon General planned wisely when he decided to open this National Conference on Air Pollution with reports from so many different industries and organizations. As I shall indicate to you shortly, this problem of air pollution presents itself to automotive people somewhat differently from the way it does to those in other industries. I am therefore pleased to have been offered by Dr. Burney a chance to summarize our industry policies, views, and accomplishments-to-date in this field.

Our industry has had pollution problems in many forms. What we have accomplished in eliminating pollution of air and water by factories, foundries, plating shops, spray-paint booths, drying ovens, and dozens of other manufacturing activities has had considerable technical and news coverage. The record doubtless is well known to most officials assembled here from the scores of communities in which our industry operates. (To speak of it before this body would be merely to labor the obvious.)

What I want to discuss today is something which, so far as I know, no other industry has ever been called upon to do: namely, to concern itself with how the consumer uses or misuses the product long after its sale to the public.

Throughout the 60 years of this industry's existence, its basic job has been to provide economical mobility to as many people as possible. When you consider that there are now almost 70 million motor vehicles in use in the United States alone, I think you will agree that the industry has some cause to be proud of its achievement. It has provided transportation on a scale unmatched anywhere else in the world. It has done this in less than one human lifetime, in only two generations.

In doing the job, the industry has of necessity encountered several aspects of the problems falling in the area of this conference. In many instances air-pollution problems involving motor vehicles are made more difficult—politically as well as technically—because millions of people prefer to transport themselves and their goods in vehicles powered by internal combustion engines, vehicles which they own and operate themselves, and for which they are individually responsible.

The history of this industry's accomplishment in the field of air-pollution control begins with the first automobile ever made.

In the course of time the problem altered. Originally it presented itself as smoke.

I am not old enough to remember those one- and two-cylinder primitives that first chugged on the scene around the turn of the century. But those who *can* remember attest to the fact that they came in with billowing plumes of smoke in their wake. Indeed, "smoke-wagon" was commonly their derisive designation. You can still see why, if you witness a demonstration of antique cars restored to their prime by proud owners today.

In eliminating smoke from vehicle exhaust, much progress has been made. True, there is still room for improvement, but mostly this must come from the owners, who alone are responsible for the maintenance of their vehicles. This is an area in which the duties as well as the rights of individual owners deserve appropriate consideration.

Historically, the next great problem of air pollution from vehicle tailpipes was that of carbon monoxide. Before this subject reared its head in the middle of the 1920's, relatively few people realized that this danger could exist even outdoors, at least on city streets, wherever there is incomplete combustion. Measurements then began to show that undesirably high concentrations of carbon monoxide existed during peak traffic congestion on heavily traveled streets in such cities as London, Paris, Berlin, and New York. Notable accomplishments in reducing this hazard were made entirely without fanfare in the ensuing years. In the decade, 1930 to 1940, reductions of as much as 50 percent were recorded in some of the areas where the dangerous concentrations were first detected. This was accomplished entirely by increasing the efficiency of fuel-burning in gasoline engines.

Documented reports of these achievements are on file in the archives of the engineering and chemical societies at whose sessions technical reports were first presented. Some of the authors of those reports are modestly in our midst in this very audience.

The advent of the high-compression engine brought a host of new problems. It demanded fuel that would burn without "knock." This demand was met eventually by gasoline containing tetra-ethyl lead. Introduction of lead in this form raised a scare about a new hazard. The result was that, after much scientific work in industry laboratories and in those of the Bureau of Mines, the top limit of lead concentration compatible with public safety was precisely determined and promulgated at a session called by the Surgeon General.

In the course of this notable work on fuels, engineers found ways to bring about better, more economical combustion: two gallons of fuel now did the work for which three were formerly needed. These findings, too, are matters of record.

All this, I would like to stress, was done primarily to provide people with economical mobility. It paid off in dividends of good citizenship; this was not overlooked by the managers of our industry.

In the past decade, our combustion specialists have had to confront a new type of monster. This one arises from certain invisible and hard-to-measure emissions which, under certain atmospheric conditions and intense sunlight, have been found to combine with portions of the air into something that is blamed for such undesirable effects as reduced visibility, irritation of the eyes, and so on.

To the extent that these effects are due to tailpipe emissions, they are as undesirable to us as to others who have to put up with them. For one thing, they are a problem involving questions of efficiency and economy. We would much rather burn all the fuel in the engine and have none of it come out of the tailpipe. So we, as manufacturers and sellers, are as much concerned as the using public.

Because of these doubly undesirable effects, our industry has authorized cooperative research which, in the past 5 years, has entailed an expenditure of about a million dollars a year. Though we've grown used to glib talk of Government billions, a million dollars a year—spent on one problem by one industry—is still a substantial outlay.

What has such an expenditure accomplished?

Because we received inadequate information to begin with, some of our engineers had to watch certain problems turn into mirages, just as they were ready to provide good solutions.

Despite such disappointments, however, the managers of our industry ordered the expensive exploratory work to continue. We are committed to it as good citizens and good neighbors, although we recognize that the problem is a regional one.

Our people have recently developed some other devices which, in the laboratory stage, show promise. These will be reported to you in appropriate technical sessions this week. Should any become practical enough to be put into production, they will of course be marketed.

Basic studies of combustion have been made and reported. These include attempts to find causes of undesirable emissions. Some seem to be—in our present technology—unavoidable emissions. At the moment, motor vehicles in the hands of owners and users are being studied to determine whether maintenance procedures can reduce typical emissions to levels that prevail in cars taken at random from well-maintained fleets. In other words, every aspect of chemistry, devices, and maintenance procedures is getting consideration.

So, as I indicated earlier, we are now getting into the realm in which the individual car-owner's free choice of how he uses—or abuses—his car, his private possession, is an issue. The problem tends to become social and economic, and therefore beyond the sole province of the engineer and scientist.

I wish I could stand before you today and report that all problems of exhaust pollution have been, or are about to be, solved. I regret that I cannot. But I can say to you that what you will hear in the several meetings here, from competent authorities in our industry, should indicate that substantial progress is being made.

I think we have good cause to hope that all this research will one day help us discover what causes these undesirable effects, and find what is needed in every air-pollution area in order to control it.

An older colleague of mine likes to scoff at those who express alarm about air pollution in American cities of today. "If people of this age could only smell a city, *any* city, in the United States of 50 years ago," he says, "they would never again wax sentimental about what are called 'the good old days.' "

It must have been impossible for our elders to imagine life in this land without the polluted air in which they lived—before people were liberated from the congested cities by the motor vehicle and the pavements it demanded and eventually got.

There were reeking livery stables in every neighborhood.

Cow-barns were the customary auxiliaries to dairies.

There were malodorous privies in every backyard.

Many city families maintained their own pig-sties and poultry yards.

The dirt in the unpaved streets was, therefore, a fetid compound of filth, laid down by successive generations of people and animals.

There were few screens on doors or windows to bar marauding, disease-bearing insects.

Yet this world, in which such filth-originated diseases as typhoid were common and regular visitors, disappeared in the smoky haze of the very automobiles which chugged erratically on the scene only one lifetime ago.

The stench vanished with the opening up of modern transportation and accompanying technologies, as the city exploded into the surrounding country.

It is difficult for us to imagine that vanished world, and the air pollution that was its accepted odor. Yet, if we would retain the calm and dispassionate attitude that the scientific method demands, we should try to remind ourselves that the evils afflicting us are perhaps mere pinpricks in contrast to those borne by our ancestors.

As I said earlier, we have good cause to hope that research shall one day help us banish those evils as well as it closed the door on the earlier ones.

To avoid the emotionalism that all too often confounds our best efforts to correct any evil, such reflections upon "the good old days" may help us immeasurably.

I feel that I should not end my remarks without assuring you that our very presence at this meeting is in itself a demonstration of the continuing concern of our industry over all phases of air pollution.

May I remind you that this is not an isolated instance of teamwork between companies in this most competitive of industries?

Experience has taught that, when the best interest of the public clearly demands it, such cooperative effort in scientific research brings the greatest good to the greatest number of people. It has worked in the past—in peace and war. It got standards fixed for materials and parts used in motor vehicles. It got roadbuilding started at long last in this roadless land. It sought and found ways and means to improve highway safety. It helped arm the Nation for defense in three wars. We sincerely believe that, if we continue to apply to this particular research the voluntary cooperation of those of our people whose technical competence has been refined by competitive endeavor, it will some day solve the problems of air pollution—those of today, as well as any that may emerge tomorrow.

Accomplishments in Air Pollution Control by the Chemical Industry

Gen. John J. Hull
U.S. Army (Retired)
President, Manufacturing Chemists' Association, Inc.
Washington, D.C.

I am honored to speak on behalf of the chemical industry at this National Conference on Air Pollution. The chemical industry certainly has been, and will continue to be, one of the leading partners in solving the problems of air pollution and it welcomes this opportunity to join with other interested groups in open discussion. There has been a lot of talk about air-pollution control. We in the chemical industry have changed or broadened our thinking in this area. For some time now we have been thinking more in terms of air-pollution avoidance.

The time appears ripe for a full, national discussion of this problem. Air pollution continues to hold widespread public interest. There has been considerable progress in the avoidance of air pollution, and we should acquaint the public more fully with this program. Although the severity of air pollution in many places has been decreased, the rapid growth of our population, our cities, and our industries has increased the number of places with air-pollution problems, thus reaching more people. There are new technological problems of air pollution which require intensive study; and there are new proposals for control laws and regulations, both of which should be carefully looked into by all groups represented here today before action is taken. These factors certainly pose the need for widespread understanding and knowledge, and I know of no better, quicker way to reach such understanding than through open discussion in a conference like the one we are participating in here.

The condition of our atmosphere, the air we breathe, is of universal interest and is one of our most important natural resources. I know of nothing else of such continuing personal concern to every living person. Any approach to air pollution must start from this fact.

From this central fact it follows, for the chemical industry, that the avoidance of air pollution and the proper use of air is a condition of doing business. Any chemical producer knows that he cannot use a process which will endanger the health, safety, comfort, or property of his neighbors.

The fundamental attitude of the chemical industry toward air pollution is embodied in two statements in the MCA publication, "A Rational Approach to Air Pollution Legislation." These are:

> 1. Pollution of the atmosphere, to the extent that it creates a nuisance or has a detrimental effect on health or on property and its utilization, shall be unlawful.

2. Responsibility for the means of correction or avoidance of emissions shall be the responsibility of the owner or operator.

Whether or not these precepts have been adopted into law or regulation in various localities, they are the guiding policies toward air pollution of the MCA and all responsible chemical company managements. These policies go back to something else which is fundamental in chemical operation.

Chemical producers know from the outset that many of the substances they use or produce are hazardous in some way. Therefore, safety of employees, neighbors, and customers must be a primary consideration. I know of no other activity where the concept of safety is so continually and thoroughly considered. This knowledge of hazard and attention to safety in all phases of operations undoubtedly accounts for the fact that the chemical industry has one of the best safety records in the world. This intimate knowledge of the technology of chemical hazard, plus the ingrained attitude of safety, has fitted the chemical industry unusually well to deal with the problems of air pollution.

In chemical production the avoidance of pollution begins in the laboratory development of a process and continues into plant and process design and through operation and maintenance. Dollars are not too accurate a guide to achievement in this field, but we do know that the investment in equipment to avoid air pollution, and the operation of such equipment, represent a very sizeable cost in the production of chemicals. These costs, of course, vary widely depending on the type of chemical production. We have surveyed the engineering departments of a represenlaive group of our member companies—small, medium, and large, and representing a variety of types of production. The lowest estimate we have received for the cost of air-pollution control or avoidance on a company basis is from 1 to 1½ percent of all production costs. These include amortization of investment in equipment, operation, and maintenance. If we use only these lowest estimates, we can conservatively estimate the chemical industry expenditures for air-pollution control or avoidance at from $200 to $250 million a year. These figures, incidentally, do not include costs of the large amount of research carried on by chemical companies.

The development of new processes is one of the key factors in the chemical industry's successful attack on air pollution. As most of you know ours is a highly competitive industry and the development of new and more efficient processes is a continuous effort. Occasionally this improvement in efficiency results from the profitable use of byproducts that formerly were wastes. Since the investment in pollution control equipment and the cost of its maintenance are frequently so high, chemical engineers are constantly searching out ways to eliminate the need for such expenditures. Of course there are continuing efforts to improve control in older processes and operations which still have useful life; and it is necessary to design, install, and operate control equipment in new processes where the process itself cannot avoid generation of pollution. The costs of good will, public relations, plant location, and compliance with regulations also come high for the chemical industry, and therefore, it is good business for the chemical producer to avoid air pollution as much as possible.

Far more important than the dollars spent are the real accomplishments our industry and others have made in the control and avoidance of air pollution throughout the country. When one considers how much industry has grown in the past 20 years, and how much improvement there has been in the atmospheric conditions of some of the great metropolitan centers where industry has grown the most, these accomplishments are obvious.

I do not mean to imply, however, that the problem is not still very much with us. Our industry feels it must continue extensive programs of research and education. The advance of technology continues to create new problems, and some old ones have not been satisfactorily solved. If only because of the know-how we have gained, we have the obligation to help solve air-pollution problems not directly connected with chemical production. We also have the obligation to help regulatory officials and legislators in drawing up and administering laws and regulations which are workable and realistically in the public interest.

The chemical industry, through the Manufacturing Chemists' Association, has conducted an active program of education by conducting workshops and conferences for people of the industry and regulatory officials. One of its soundest accomplishments in this field has been the publication of the MCA Air Pollution Abatement Manual, a definitive compendium written by experts in the field and kept up to date through frequent supplements. This manual is a standard reference of most chemical companies and of many others not directly associated with the industry.

Because the condition of the air we breathe is of such importance to everyone, it is properly a matter of public regulation and control. In developing such public controls it is necessary to consider a wide variety of complex problems. These include: a technology which is still far from complete; geographical units which may ignore political boundaries, and many of which have problems peculiar to themselves; the great number of sources and kinds of air pollutants, many of which are not caused by man; the income sources of a community and industrial employees; and even the vagaries of the weather. From the standpoint of technology the problem is of national interest, but from the standpoint of control it is currently local or regional.

It is our belief that any law providing for the control of air pollution should embody the following principles:

1. Provision for the initiation of governmental action and for control on a local basis, preferably by local governmental units.
2. Establishment of a State organization for technical assistance, to resolve jurisdictional problems, and to investigate and recommend corrective measures for pollution in local areas when requested to do so by local political units.
3. Recognition of the appropriate role of Federal agencies and provision for cooperation on a national and international level.
4. Provision for rule making and enforcement in such a manner that the separation of legislative, administrative, and judicial functions of Government are preserved fully.
5. Provision for registration of sources of emission.
6. Authority for reasonable rights of entry.
7. Provision for cooperation in technical advancement.

To help solve these difficult regulatory problems, MCA has prepared the booklet I previously mentioned, "A Rational Approach to Air Pollution Legislation." This booklet has been provided to many Federal, State, and municipal officials. If you would like a copy, please drop me a line. In addition, the MCA makes available experts in the air-pollution control field to such officials in their preparation of legislation or regulations. A number of people from the chemical industry have performed outstanding public service as members of State or municipal air-pollution control boards. MCA representatives have testified before congressional committees considering Federal legislation in this field and have actively cooperated with governmental and private research agencies. In this connection I want to take this opportunity to applaud the work of a number of these agencies. Their scientific investigation of all sources of air pollution and methods of control are essential to solving this important problem.

The area of scientific investigation offers probably the best hope for sensible and effective control of air pollution. But it ties in with another area of equal importance—that of public understanding. In my opinion this is the part of the problem where we have been the least successful, and I think all of us share the blame. There is ample evidence to show that the layman, the citizen not acquainted with the technology, has a fear of air pollution out of all proportion to facts as they exist.

Our problem of air pollution cannot be sensibly solved without honest, accurate public understanding, and this imposes a very important responsibility on all of us connected with the problem. This requires people in industry not only to do the best they can to avoid air pollution but to be honest and forthright in these matters in their dealings with the public. It requires scientists not just to talk among themselves but to make their knowledge understandable to the public whom it concerns. This public understanding is a special responsibility of the press and other communicators. Objective reporting based on full scientific knowledge of the facts, with understandable scientific conclusions, is the only kind that will assist in making real progress.

The march of American history has proved time and again that an honestly informed citizenry is the best guarantee of a solution to such a national problem. I earnestly hope that everyone at this conference, and anyone interested in the progress of air-pollution control, will remember this obligation and regard it as a sacred trust.

Accomplishments in Air Pollution Control by the Petroleum Industry

Dr. Jerry McAfee

Vice President, Gulf Oil Corp., Pittsburgh, Pa.
Chairman, Smoke and Fumes Technical Advisory Committee
American Petroleum Institute

The petroleum industry has been concerned about air-pollution control ever since the first refinery began operations. Although economic considerations alone dictate that loss of volatile products by evaporation to the atmosphere be held to a very low level, current operating practices in the control of air pollution usually go far beyond the requirements of economics. Refiners make a vigorous effort to be good citizens in the communities in which they operate, and they are fully aware of their responsibilities with respect to the health and comfort of their neighbors. The extent of their efforts can be measured by the fact that since 1956, the industry has spent an estimated $66 million on air-pollution control, plus an additional expenditure of about $1 million per year for research.

To an ever-increasing degree, everyone in the industry, from top management down, is interested in preventing pollution. In August 1955 a letter to the vice president for refining, American Petroleum Institute, from the chairman of the Smoke and Fumes Committee and the chairman of the Committee on Disposal of Refinery Wastes set forth a "pollution control policy." The following is a quotation from this policy statement. "It is suggested that, in view of the recognized importance of adequate pollution control, members of the General Committee undertake the responsibility of seeing that all members of their respective organizations are fully aware of their pollution-control policy. It is our belief that recommendations for specific pollution-control measures must, for the most part, originate at the refinery level. Top refining department management as represented by the General Committee must, however, establish the policy." Employees throughout the organization are taught to be air-pollution conscious, and management is careful to see that employees at all levels understand air-pollution control methods and policies. Whenever air-pollution control regulations are proposed, industry personnel take an active part as responsible citizens to assist in providing sound and realistic legislation.

The extent of air-pollution control required is of course dependent to a considerable degree upon location of the refinery and upon topographical and meteorological conditions of the area. A region of poor ventilation and high population density, as represented by Los Angeles, requires more stringent control than an area where these conditions are absent. A recent survey of industry expenditures for pollution control made by the *Oil and Gas Journal* reflects this situation. In others, population is so sparse that only minimum expenditures beyond the economic level are required.

Now, what are the air pollutants that the industry is endeavoring to control?

From the beginning, control of sulfur compounds has been of great interest, and each year as new plants and process units are constructed, sulfur recovery becomes more complete. Throughout the Nation the industry recovers about 1,600 tons of sulfur daily which would otherwise escape to the atmosphere. In the Los Angeles area, 600 tons/day of sulfur oxides are converted to sulfur or sulfuric acid and are thus kept out of the atmosphere. In many areas, outside chemical plants are being employed to convert hydrogen sulfide to elemental sulfur or sulfuric acid. Burning of acid sludges, with a consequent release of sulfur dioxide to the atmosphere, has been discontinued in nearly all populated areas. Sludges are converted to sulfuric acid for manufacturing purposes or to ammonium sulfate for sale as fertilizer.

Control of smoke and particulate matter is also receiving close attention by the industry. To avoid smoking stacks, many installations include smoke indicators or recorders, oxygen analyzers, and other instruments to enable close control of combustion. Where meteorological conditions indicate, stack heights have been extended to assure complete dissipation of stack effluents. Afterburners have been installed in many cases to eliminate coke fines, hydrocarbons, and carbon monoxide in the stack gases. Catalyst collection devices such as cyclones and precipitators are in use to reduce the emission of dust to the atmosphere.

The researches of Haagen-Smit and others have shown that under certain conditions, hydrocarbons and oxides of nitrogen can participate in the photochemical reactions that lead to the formation of "smog." Therefore in Los Angeles, where ventilation is poor, additional emphasis has been placed on the recovery and control of hydrocarbons. Before control can be effective, the principal sources of hydrocarbon loss must be recognized and evaluated. Individual companies, working cooperatively through industry trade associations and with control agencies, the USPHS, and others, have conducted extensive surveys of refinery hydrocarbon losses. Steady progress has been made in reducing evaporation losses from storage tanks, pumps, wholesale distributing facilities, and water/oil separator operations, to name but a few. For example, the installation of vapor collection systems and floating roofs on gasoline tanks has cut evaporation losses some 70 percent in the past few years. In instances where hydrocarbons are unavoidably released from a process unit, smokeless flares have been installed to incinerate the gas completely so that only carbon dioxide and water vapor escape to the atmosphere. Again referring to Los Angeles County, since it is the most completely documented area, the total daily loss of hydrocarbons from refining operations is less than the evaporation loss from carburetors and gasoline tanks of automobiles operating on the streets on a hot summer day.

Odor abatement is another of the important phases of air-pollution control. Throughout the petroleum refining industry the philosophy is being adopted that refineries don't have to smell bad. Incineration at high temperature to destroy such odor-producing materials as hydrogen sulfide or mercaptans and the use of air oxidation to convert sulfur compounds to water soluble salts are examples of odor control. Spent caustic soda solutions containing phenols and sulfur compounds are potential odor sources in the industry. Careful control of these waste solutions going into sewers, chemical treatment of the wastes, and, in some cases, sale of the waste materials to outside chemical companies for recovery of byproducts, has done much to eliminate the odor problem. In general, these are not profitable operations but again reflect the efforts of the industry to be good citizens in the communities in which it operates.

Ten years ago very little was known about the chemistry of the atmosphere and the mechanism of reactions leading to air pollution. Following World War II and the growth in population and industry on the West Coast, the increase in "smog" in Los Angeles County prompted regulations governing the emission of atmospheric pollutants. None of these proved effective in eliminating the nuisance. About 1947 the Western Oil and Gas Association decided to find out what really caused "smog" in the Los Angeles area. Thus began a long and expensive research program. The Western Oil and Gas Association has done a great deal to advance the knowledge about "smog" formation, and in addition, has been able to catalog pollutants from operations of the oil industry in the Los Angeles area. It has been found that oil industry operations make only a small contribution to the overall pollution problem.

The oil industry soon realized that proper decisions with regard to the control of atmospheric pollutants could not be made without accurate, scientific information. In instances where legislation is regarded as necessary, fundamental knowledge based on reliable research rather than on theory or hypothesis or opinion should be available to Government agencies to avert restrictive and uneconomic rulings of the type which might later prove to be unnecessary.

Accordingly, in 1951 the entire U.S. petroleum industry determined to supplement the already considerable efforts of its West Coast members in air-pollution research. Through the Division of Refining of the American Petroleum Institute, a "Smoke and Fumes Committee" was established to set up a program to determine factually the causes and methods of control of atmospheric pollution resulting from production, transportation, manufacture, and use of petroleum products. Research projects were established at qualified research centers to obtain fundamental knowledge of the mechanisms leading to air pollution. To date, the API's research expenditures in this field have exceeded $1.3 million, and the work is continuing at a substantial level. The combined expenditures of the API, the Western Oil and Gas Association, and numerous individual companies result in an estimated total of more than $1 million per year being spent by the petroleum industry for research in the air-pollution field. The following examples illustrate the type of work being done.

At the Franklin Institute research into the nature of chemical reactions in the air leading to atmospheric pollution has produced outstanding results. The design and construction of the long-path infrared spectrometer (popularly known as Silent Sam, the Smog Detective) has placed a tool in the hands of scientists to permit measurement of materials in the atmosphere at concentrations in the parts per million range. The Franklin Institute studies have substantiated earlier findings that hydrocarbons and oxides of nitrogen in the presence of oxygen react under the influence of sunlight to form ozone. In the course of these investigations, a new organic compound, peroxyacyl nitrite (Compound X) was identified. It was originally suspected as the material responsible for eye irritation, but subsequent research has shown it to be an intermediate compound in atmospheric reactions.

Oxidant-type damage to vegetation is one of the manifestations of "smog." This damage is unique and is believed to be caused by oxidized organic materials. The damaging substance has not yet been identified, but API-sponsored research at the University of California at Riverside is in progress to study the reactions of ozone and hydrocarbons in an attempt to identify the materials responsible.

As mentioned earlier, sulphur compounds have long been recognized as sources of air pollution. Sulfuric acid aerosol has been suggested as one of the causes of reduced visibility accompanying air pollution. At the University of Illinois, a research project sponsored by the Smoke and Fumes Committee clearly demonstrated that the uncatalyzed gas-phase oxidation of sulfur dioxide in naturally polluted atmospheres in natural sunlight was not sufficiently rapid to be significant in effectively reducing visibility.

The use of petroleum products as fuel is continually increasing in both domestic and industrial heating devices. Many questions have arisen as to the nature and extent of air pollution from such sources. At the Armour Research Foundation, both laboratory and field trials of industrial and domestic burners were conducted to determine the quantity of pollutants emitted. Analysis of the gaseous effluents led to the conclusion that neither domestic nor industrial furnaces burning oil or gas release significant amounts of hydrocarbon contaminants to the atmosphere.

Other research activities sponsored by the Smoke and Fumes Committee have included an air analysis program in several U.S. cities showing that the oxidant level of Los Angeles is abnormally high by comparison; analysis of gaseous compounds in the atmosphere to determine the sources of atmospheric carbon; the development of gas chromatographic methods of analysis for the determination of the composition of exhaust gases; the demonstration of a successful technique to trace air pollution from a single source; and the development of a method of detection of ozone suitable for use in continuous, portable instruments.

Recently automobile exhaust has been singled out as the principal contributor to air pollution of the type found in the Los Angeles area. In June 1957, the Smoke and Fumes Committee of the API joined forces with the Air Pollution Foundation to study this problem. Both fuel composition and automobile variables have been studied in a system designed to evaluate eye irritation, visibility reduction, and ozone formation as well as the chemical properties of the pollutants obtained from photochemical reactions. Automobile exhausts from fuel mixtures representing extremes in composition of the hydrocarbons of the types found in gasoline were compared with exhausts from a blend of commercial gasolines. The results of these studies have demonstrated conclusively that the exhausts from all fuels tested produce recognizable symptoms of air pollution when irradiated. While some differences in the exhausts produced by different fuels were found, the exhausts from all of the fuels tested produced substantial eye irritation when irradiated, and each produced the same maximum concentration of ozone. It was further demonstrated that eye irritation, visibility reduction, and ozone formation from automobile exhaust are affected as much by differences in automobiles as by differences in fuel composition.

The petroleum industry attempts to control pollution voluntarily rather than await compulsory rules and regulations. Because more information is available about the Los Angeles situation, lawmakers may tend to look to this area as a source for control regulations. It has been pointed out that the Los Angeles Air Pollution Control District attempts to keep its actions within the limits of current scientific developments. For this they are to be commended. Nevertheless, no community should attempt to pattern a control system after the Los Angeles plan until the need for each regulation has been thoroughly explored. The tendency to adopt entire sets of regulations from another area can lead to programs which unnecessarily impede the progress of the entire community.

Enforcement of air-pollution control laws under the permit system—as practiced in Los Angeles—requires air-pollution control before it is proved that such controls are necessary. On the other hand, an injunctive system based on civil action prevents the needless expenditure of funds for costly controls until it is shown that a pollution problem really exists.

In the past 10 years the oil industry has learned a lot about the nature of air pollution and its control. The history of air pollution as related to the industry has revealed scientific facts from which everyone concerned with the problem can benefit. It is clear that air pollution cannot be simply legislated out of existence. Causes, sources, and methods must be known. Control regulations satisfactory to one community should not be adopted by another as the "easy way out." It may be the easy way but also the most expensive and the least satisfactory. The problem must be defined before a solution can be found.

The petroleum industry throughout the Nation is continuing to cooperate with local authorities to determine the problem in each local area concerned and to do everything in its power to reduce air pollution caused by the industry. We know we are making progress, because emissions from the processing of petroleum have been drastically reduced.

The air-pollution nuisance can only be overcome by the cooperative effort of everyone concerned: industry, Government, scientists, and the private citizen. I am certain the petroleum industry will continue to do its share.

Dinner Meeting—Tuesday Evening, November 18

Presiding:
Dr. Abel Wolman
Professor of Sanitary Engineering
Johns Hopkins University
Baltimore, Md.

The Other Side of Science

Dr. Edwin D. Harrison
President, Georgia Institute of Technology
Atlanta, Ga.

In telling you about "The Other Side of Science," I am frankly going to try to make a defense for the technologist and the scientist and the engineer and all the people in the related fields. Many of you, I am sure, already know that it is not at all unusual today to measure strains or changes in the length of a piece of metal to the millionths of an inch, a very short dimension, or to measure intervals of time down to a millionth of a second. So commonplace is this latter that there are hundreds of airplanes flying the Atlantic Ocean every day which make use of a navigational device called Loran, in which an operator by measuring a couple of pips on an oscilloscope is able to measure the difference in time of the reception of 2 radio signals from stations which may be 500 to 1,000 miles apart on the mainland. By measuring that time difference, he is able to measure a chart and find a line along which his plane is located. By flicking his switch to another pair of stations he is enabled to do the same with a second set of stations and that gives him a second line, and from that he is able to determine his whole position. The whole procedure will take him something like 40 seconds. Those of us who learned to use the stars and get a 3-star fix in 30 minutes can certainly appreciate this remarkable side of science and the way it has improved in the last few years.

I am sure most of you know that airplanes today carrying human beings have made speeds better than 1,500 miles per hour, probably 1,800 miles an hour, or close to it, but you don't know how fast that it. That is approximately seven football field lengths in a second. That is going pretty fast. And yet I can remember very vividly, when I was living in Cheyenne, Wyo., and in junior high school there a few years ago, a fellow named Frank Hawkes took off in a plane from Cheyenne and sent a telegram to Denver to inform the people in Denver that he was coming, and he arrived before the telegram.

A distance of 100 miles, and he made the flight in exactly 50 minutes. He traveled at the fantastic speed of 2 miles a minute. Think of that! At that time I was so astounded, I was so upset by the possibility of a man moving that fast, that I wondered what would happen to him if he should turn a corner and be thrown against the inside of the airplane and be completely demolished. Apparently he flew the plane in a straight line.

I fly a Cessna 180 from time to time and in that, 100 miles an hour is not too unusual. Frank Hawkes had a special racing plane. I fly along, in all comfort, with air conditioning, and with radio equipment so we can talk without difficulty to people on the ground, 150 to 200 miles away. That is a far cry indeed from Frank Hawkes' experience.

In 1885, about the time the institution which I represent was founded, a man appeared before a joint congressional investigating committee—there were such committees in those days, too—and recommended that the Patent Office be done away with. He said everything that could possibly be invented had already been invented and there was absolutely no sense in maintaining the Office when nothing remained to be discovered. That is an interesting story, because the man who made the recommendation was in charge of the Patent Office. That is an amazing thing from two points of view: he didn't have enough vision to know what was coming, and can you imagine a civil service man eliminating his own job!

In 1776, only 8 of every 100 people in America were able to engage in pursuits that were not directly connected with the raising or distribution of food. Ninety-two out of every 100 people worked on the farm or processed the products of the farm in order to keep themselves and the other 8. That was when this country was founded. Today, in 1958, those two figures are exactly reversed. Today there are 8 people working on the farm feeding themselves and the other 92. I am going to refer back to this in a little while, because the improvement in the planting, tilling, harvesting, the preparation of seed and grain, preparation and storing of foods, and so on, has been brought about through contributions made by technology and science.

You read the story of the nuclear submarine recently that traveled under the polar ice cap. It is more remarkable to me that that submarine traveled 75,000 miles and, as one magazine tells me, it used approximately one bucket of fuel in doing that.

A nuclear ship is being built, the *Savannah*. You remember that was the name of the first steamship that crossed the ocean. It didn't steam across the ocean. It steamed until it got over the horizon, and then they put the fire out, put the sails up and sailed until they got almost to where they were going. Then they reversed the process, put the sails down, built up the fire, and steamed into port. The *Savannah* carried enough fuel to last 90 hours, and traveled at the fantastic speed of 9 knots. That meant it could travel 450 miles if it carried all the fuel it could and all the people necessary to manage it. Think of that. Yet this nuclear ship, which will be launched in 1959 and make a world tour in 1960, will not have to refuel, once the reactors are put into operation, for a period of over 15 months.

The popular conception of science, however, as many people understand it, is directly related to destruction—the intercontinental ballistic missiles, H-bombs, and such things as that. I have a quotation from a newspaper which represents the kind of picture people have, the impression I have to fight in order to keep the great American public from believing that science is all destructive. It is an article from the *Atlanta Journal:*

> So we have got to catch up and then outdo them (the Russians) even if we have to take every automobile salesman, every little potential salesman, by the scruff of the neck and make a scientist out of him, and turn every embryonic journalist into an atom splitter, and every preacher or philosopher into an expert on guided missiles.

Notice the emphasis in there on "everybody has to be a scientist," and the emphasis on the destructive effects of science—the atom-splitting and the missiles.

We had a Governor's Conference on Education a couple of weeks ago. One of the speakers at that conference was one of the outstanding educators in my State, and he got up and told these people that we had to be mighty careful how far we went in the direction of this science business. There are some terrible things that could happen. For one thing, this carbon monoxide that is poisoning the atmosphere was being produced in such quantities that the air all around the earth would be filled with it and everybody would get poisoned. As bad as it is, I think that is an exaggeration.

He said that the heat from automobile exhausts will raise the earth's temperature by 5 percent, and by doing this it will melt both the ice caps, raise the level of the ocean 100 feet, and flood Miami. I contend this gentleman does not know what raising the temperature of the earth's atmosphere 5 percent means. I don't think he knows that those things on the thermometer aren't percents but degrees, and I don't think he knows how difficult it would be to produce enough heat to raise the temperature on all the surface of the earth by 5 percent. Anyway, he scared the daylights out of some of the people who were there.

He also said that some of these rockets, as they shoot off into space and push themselves into orbit, push the earth also. This fellow never heard of Newton's second law, or was it the first law, that for every action there would be an equal reaction. A rocket does not go into orbit by taking all its push from the earth—granted that that first push may push the earth out a little bit. But I mentioned to that fellow, "Every time you jump up into the air, do you know that you push the earth out, too?" That fellow walked around as if he were walking on eggs all the rest of the conference there.

He told me with authority that the amount of radiation in the atmosphere right now was sufficient to cause 10 percent harmful mutations in man. I don't know where this fellow got all this information.

Incidentally, he later quoted H. G. Wells in his speech. But he ended up his remarkable dissertation on science by saying that what we need are poets and thinkers to control science. Thinkers; not tinkers. Now I don't believe this gentleman knows an awful lot about science.

But I am amazed, because in that audience, which was as large as we have here tonight, about 85 percent of the people who were there bought everything he said and they came out of there just terrified. The earth was out of its orbit, they were all getting poisoned, and the ice caps were going to melt and drown everybody in Florida. They were really quite upset.

Don't you think it would have been a whole lot wiser in discussing such things for this noted scientific educator to have said: "Wouldn't it be nice to have our children be more like the kind of people Edison or Jonas Salk are? Or Steinmetz or Fleming, or Pasteur, or D. B. Steinman? I believe it would have been far more valuable for that man to have looked at the other side of science rather than to dwell as he did on the terrors that he envisioned were going to take place.

Now I have another quotation, and this is not to kill time but because these quotations make points. This one is by a gentleman named Bertrand Russell, with whom I may not always agree, but in this case I do agree with him: "If Homer and Aeschylus had not exhorted, if Dante and Shakespeare had not written a line, if Bach and Beethoven had been silent, the daily lives of most people in the present day would have been much what they are. But if Pythagoras and Galileo and Jack Watt had not existed, the daily lives of not only the Americans and the Europeans but also the Russians and the Chinese peasants would have been profoundly different from what they are, and these profound changes are still only beginning. They must affect the future even more than they have already affected the present." Of course I have taken Bertrand Russell's quotation out of context.

He went on to say that of course it takes more than just scientists to make the world a happy place to live in, it takes more than just technicians, and yes, more than doctors and more than people who do any one other thing, and of course I agree with him wholeheartedly in that. But I do believe that there is a great deal of truth in that quotation of his, too.

Suppose I were to ask you whatever became of tetanus, of smallpox, yellow fever, or polio—except in Detroit or some place like that? And what about the Air-Sea Rescue Service and the contributions it has made? How about aerial planting and aerial seeding, making of rain, aerial firefighting? What kind of contribution have they made to the welfare and economy of the country? How about modern food production, which is the most fantastic thing of all? The manufacture of paper that makes it possible for you to be completely flooded with reading material, some of which is worth reading? Or the invention, manufacturing, and distribution of printing presses, and the material that comes from them? And mass transportation, which you may not consider to be very wise, but which made it possible for me to be here today. At 1:00 o'clock I was traveling to the Atlanta airport and, after stopping at Charlotte, I was up here getting off the plane at 4:15. So the transportation that we see all around us is so commonplace as to become almost natural and we don't even give it the kind of thought it is entitled to. Nevertheless, that is one of the things that have made the world the kind of world we live in today.

Where does the time come from that makes possible the hatching—I started to say "spawning" but I thought that didn't fit—the hatching of journalists and philosophers, the merchants, the manufacturers, the musicians and the physicists, the engineers and the scientists, and so on? What has made this possible? Why is it that in 1776, 92 percent of the people were so busily engaged in keeping from starving to death that they couldn't possibly do anything else? And yet today 92 percent of the people are busy going to conventions and running around the country and living it up and having a big time. I think this has been made possible through tremendous changes in the kind of culture in which we live. Please don't misunderstand me: I am not trying to tell you that these hard goods are what makes the country great; I am only telling you that through these hard goods we are able to have more time to devote to the other things, and some of these people are going to use the time to do something good.

In 1850, 75 percent of all lifting, pushing, hauling, and so on in American life, call it three-quarters, of our work in America was being done by muscle power—human and animal. And in those days a man worked usually a 70-hour week. Today only 6 percent of all lifting, hauling, pushing, and so on, is done by muscle power, man and animal, and man works only a 40-hour week. It gives him a great deal more time for thinking.

Let me name some more scientific horrors for you that my friend should have learned about. These would include such things as the iron lung, the antibiotics, the blood plasma—which was honestly, really invented by the Russians—and the X-ray, radioisotope research—I could go on and on and on about these contributions that have been made, which have made it possible for a number of people to be released from the cold, hard process of just staying alive and having enough to keep from starving to death and enabled to have some spare time to devote to other pursuits.

My whole theme is this, that science can contribute, and its contributions far outweigh that one which many, many people fear, and that is the defense aspect, all-out atomic war, and all those things.

I honestly believe that a little bit of science would do good to everybody. I recently heard the president of Republic Steel say that he felt every businessman should have at least a nodding acquaintance with scientific information. I would go further than that and say that people who drive automobiles, for example, people that try to make electrical repairs around the house, people who do many things in modern life, ought to have some understanding of science. Some of the most ridiculous impasses result if you don't have this understanding. I am sure all of us at one time or another have stood vigorously on one side or the other of the fluoridation fence. Now I am not going to argue for either side, but anybody who opposes it is cracked.

Up in Monroe, Mich., a group of power companies were brought together to try to build a reactor. It was a noble experiment, and it is; it is a new type of reactor, a breeder reactor, something that might possibly produce power and at the same time produce additional fuel, a kind of a ridiculous situation but one that has been demonstrated as possible. A leader in that part of the world said he would not have such a reactor around there because it was going to blow up some day and blow Detroit off the map and kill all those nice, happy members. And honestly, the members of the AEC Reactor Safety Division would not permit the construction of such a reactor unless it had been tested carefully, with all the possibilities of radiation assayed and explosion damage investigated thoroughly—but that didn't make any difference to the person who posed the greatest objection to putting such a reactor there.

You would be amazed if you knew how many people are killed in electrical accidents every year. I looked up this figure a couple of weeks ago and I have forgotten it and I am afraid to give a quotation because I will be maybe a little bit off, but a tremendous number of people still believe that you can stand in the bathtub, and reach out and pick up an electrical heater.

A lot of people can sit behind the steering wheel of the car and reach over with their toes and touch a little gizmo and they fly down the highway, and everything is swell until something goes wrong. In my State alone last year from January 1, 1958, until today we have killed 700 people in highway accidents. That is more people than have been killed in all commercial aviation accidents to date. And I am only talking about the first 10 months of this year in 1 State. And most of those people who drive that way have no idea how far they actually have to go to stop: they have no idea how much energy is stored in that hurtling ton-and-a-half piece of metal. They hurtle along, and probably some guy pulls out on a blind curve in the middle of the road. What do you do? I hope all your payments are up to date, and if you haven't got your will made, you ought to take care of that too.

I believe a little knowledge of science would be valuable to everyone. I believe it has applications in everyday life. I believe it has applications in your political life, I believe it has applications in your national life, whether it be fluoridation or what we do with the atomic bombs.

I don't mean everybody should be a scientist or engineer, and when I say "scientist" I include all the aspects of science—physicians, dentists, biologists, and all the specialists that that term includes—but I do believe it would be a fine thing if approximately 1 in 15, or 1 in 10—that is, approximately 6 to 10 percent—of the people who go to college would specialize in science, we would have all of the technically trained people that we can use effectively in this country today.

Then down in Georgia there is a place called Carrolton which I visited recently, and I believe it was one of the most moving experiences of my life. There was a two-room schoolhouse out on the hill, called the Bart Mountain School, and a minister got interested in finding out whether or not you could teach science to children. In this school they took kids from a little one-room school building next door, and they gave them classes in this little old two-room building which was about to fall down, beginning with the third grade, and it is most remarkable to see how much those kids absorb. It is an amazing thing that they have done. Instead of having the kids when they are 4 or 6 years old or so ask "Why, why, why?" all the time and then when they are 16 say "Who cares?"—I hope it will develop a group of children who will be really interested, and from this group will come not a large number of scientists—no, indeed—but there will come some who are interested enough to want to go ahead.

One of the great fears of the educationists is that we are going to go overboard on the science thing. You know it all started with Sputnik, when that came along. They keep saying, "Let's don't go too far, let's don't go too far." You can't go too far until you get started, honestly you can't, and I would like to see us get started. That is all I am really concerned about.

Let me leave you with these two thoughts: not all science is evil; much of what it contributes is good. The other thing is I didn't say everybody should be a scientist; all I ask is that somewhere between 6 and 10 percent of those who go to college should major in science.

Objectives of the Air Pollution Control Association

Arnold Arch
Niagara Falls, N.Y.
President, Air Pollution Control Association

As president of the Air Pollution Control Association, popularly known as APCA, it is a privilege and an honor for me to be here tonight.

Since the Air Pollution Control Association is the only technical society which has as its sole purpose the control of atmospheric pollution, we are delighted, indeed, to participate and to be a part of a conference which is national in scope such as this one.

The Air Pollution Control Association and the Public Health Service have worked very closely together in connection with this national conference. Both groups enjoy close liaison in working toward our common objectives. For example, about 3 years ago, APCA started a publication of abstracts on air pollution. It was my great pleasure to sign a contract which has recently been negotiated between APCA and the Public Health Service for a joint monthly abstract service starting this month, of greatly expanded coverage in the field of air-pollution control. This joint undertaking, which will combine the resources of both organizations, will result in an improved publication to widen the coverage of the field.

In these brief remarks, I would like, if I may, to dwell for a moment upon the purposes of the Air Pollution Control Association, which is now in its 52d year. APCA aims to foster the control of atmospheric pollution and to improve the sanitation of the air. We also encourage public and industrial acceptance of the necessity for atmospheric pollution prevention and we assist governmental units toward a solution of this problem by encouraging the development and adoption of equipment, and operating procedures, that will economically prevent pollution of the atmosphere.

We also encourage the participation, cooperation, assistance, and support of industry, of technical, civic, governmental, and medical societies, as well as health associations, and other organizations in air-pollution prevention activities. We encourage the development and adoption of engineering standards of performance on a national and international scale that are workable and reasonable, and promote research in the solution of problems embracing all sources of atmospheric pollution.

We aid municipalities and public bodies in formulating regulations controlling the discharge into the atmosphere of harmful contaminants, and prepare and distribute literature and publications pertaining to the problems involved in providing cleaner air; and in addition, maintain a library and information service of professional papers, technical articles and publications, and descriptive material pertaining to cause, effect, and remedy involving atmospheric pollution. This is the program then, in brief, upon which our organization of more than 1,700 members is building. Membership is available to anyone interestesd in air pollution.

Last week in Pittsburgh the technical coordinating committees and technical council of our association had their semiannual conference. It is the duty of these technical coordinating committees to establish definitions, methods, processes, and procedures, as well as to recommend practical limits of atmospheric contamination for the guidance of the membership of our society.

These technical committees are composed of a good cross-section of our entire membership, including control officials, representatives of industry, manufacturers of control equipment, and research, educational, and governmental personnel. At least partially as a result of this cooperative effort, industry is now spending huge sums every year in an effort to reduce its share of atmospheric contamination. Some estimates as high as $500 million per year have been calculated.

In conclusion then, once again for myself and on behalf of the members of the Air Pollution Control Association, I wish to congratulate the Public Health Service for a fine conference, and I hope that we may look forward to other joint efforts in the future as well.

Second Day
DISCUSSION GROUP SESSIONS

Wednesday, November 19

DISCUSSION GROUP "A"
EXTENT OF AIR POLLUTION

Chairman

Dr. Arie J. Haagen-Smit
Professor of Bio-Organic Chemistry
California Institute of Technology
Pasadena, Calif.

Vice Chairman

Dr. Herbert C. McKee
Manager, Air Pollution Research, Southwest Research Institute
San Antonio, Tex.

Public Health Service Resource

Arthur C. Stern
Chief, Air Pollution Engineering Research Staff
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

Members

Charles E. Couchman, City Health Department, Baltimore, Md.; Chairman, American Conference of Governmental Industrial Hygienists.

P. N. Gammelgard, Vice President, Refining, Pure Oil Co., Chicago, Ill.

Dr. H. Fraser Johnstone, Department of Chemistry, University of Illinois, Urbana, Ill.

Frank A. Patty, Research Staff, General Motors Corp., Detroit, Mich.

Wilber E. Smith, Assistant Director, American Municipal Association, Washington, D.C.

Elmer P. Wheeler, St. Louis; American Industrial Hygiene Association.

Theme

"What's in the Air—Today and Tomorrow?"

Questions for Discussion

1. Where do we stand in our knowledge of:
   - (a) the identity and quantity of pollutants in community atmosphere?
   - (b) the trend in change of such pollutants and their pattern of distribution?
   - (c) the specific effects of various topographic and meteorological conditions and of concentration or dispersal of sources on the concentrations of such pollutants?
2. What, if anything, should be done further on these matters, and by whom?

When Is Air Polluted and Why Is It Necessary To Measure Air Pollutants?

Dr. Arie J. Haagen-Smit
Professor of Bio-Organic Chemistry
California Institute of Technology
Pasadena, Calif.

Problems in air pollution branch out into fields varying from mathematics to psychology. Its subjective nature becomes immediately clear when one tries to define air pollution. We may say that air pollution is any deviation from the normal composition of the air which affects us adversely, or more shortly, anything we don't want in the air. For a more departmentalized use a recent definition of community air pollution was given as follows:

"Community air pollution is the presence in the ambient atmosphere of substances put there by the activities of man in concentrations sufficient to interfere directly or indirectly with his comfort, safety, or health, or with the full use and enjoyment of his property. In general, it does not refer to the atmospheric pollution incident to employment in areas where workers are employed, nor is it concerned with airborne agents of communicable disease, nor with overt or covert acts of war."

The subjective nature of the experience is especially noticeable, and also frustrating, to an air-pollution control official when we come to the field of "nuisance effects." What is a nuisance to one may represent only ordinary living conditions to others, and there will never be unanimity regarding this phase of air pollution. It is usually decided by a vocal minority what constitutes a nuisance and what measures will be taken for control.

We find ourselves on more solid grounds when nuisance effects are replaced by toxic ones, but even then there is considerable divergence of opinion. All chemicals, whatever their nature, may be harmful to humans when a certain concentration is reached and maintained for sufficiently long time. This is true for natural constituents of the air—oxygen, nitrogen and carbon dioxide—as well as the group of poisonous gases such as cyanides, sulfur dioxide or trioxide, chlorine, and many others.

Our concern in air-pollution studies and control is mainly with substances of this latter type, which are toxic in concentrations of a few parts per million or less. In industrial health problems local concentrations of thousands of parts per million may occur, drawing to our attention many more substances of medium or mild toxicity. The mere fact that a poisonous gas is released is not necessarily alarming. It is the quantity and especially the concentration established at ground level which determines the harmful effect. Quite often obnoxious concentrations are easily perceived through unpleasant odors, or nose, throat, or eye irritations. For example, the industrial toxic level of sulfur dioxide has been set by the medical profession at 10–20 ppm. Its presence is readily detectable at 2 ppm. by its peculiar taste and odor, which gives warning of an abnormally high concentration. The same is true for H_2S and NH_3, for which the toxic levels have been set, respectively, at 20 and 100 ppm. In both cases the odor is recognized long before adverse health effects are apparent. It happens, however, that both these gases paralyze our sense of smell, and after some exposure their odors become hardly noticeable. However, the toxicity level has not changed. There are many toxic gases which do not give any warning of impending danger. Carbon monoxide is odorless and tasteless. Some war gases actually have a somewhat pleasant odor, and the ordinary citizen has no way of knowing that he is exposed to lethal quantities of such chemicals. It is here that the chemist steps in, because chemistry and allied sciences have made it possible to determine how much of the different substances are present in the air. It is unfortunate that the environmental hygienist has not kept up with the need of relating these objective values of the chemist to physiological subtoxic and toxic effects of these chemicals.

The chemist cannot wait until reasonable limits are set for urban populations of millions of individuals. He has continued measuring the different pollutants, and in such a way background material has been collected which is invaluable for epidemiological conclusions. In the meantime, the values determined provide some safeguard when remaining below provisional standards such as were adopted in the Los Angeles area.

In general, there are three fields of chemical analysis for air pollution purposes: one is atmospheric monitoring; a second is that of source testing; and the third pertains to engineering research and development. Each one of these requires its own type of analytical tools.

In atmospheric sampling, circumstances of a financial or technical nature may prescribe the use of inexpensive testing methods—the use of dustfall jars, lead peroxide candles, rubber cracking—all indicating average, cumulative exposure to pollutants. In general, these relatively inexpensive methods are of use in following the extent and the development of pollution in a certain area, or to pinpoint certain sources of pollution. They are most useful during the early stages of air-pollution programs, when funds for adequate instrumentation are not flowing so freely. In later, more advanced stages of air pollution, public health authorities especially are more often interested in peak values, for it is at those times that accidents occur. The instrumentation for this type of determination ranges from manually operated sampling trains to continuous monitoring apparatus, which is expensive both in initial installation and in maintenance. Even more costly is the digestion of results from miles and miles of recording paper, for which skilled personnel and electronic computers are necessary merely to tabulate the material. Economic and technical considerations determine the need for these different approaches, and it is not necessarily true that the most expensive and most prolific data producer is the best choice in all air-pollution problems.

For control purposes there are still other requirements. In the first place, the concentration range in which the analytical chemist must work in source testing is usually higher by a factor of a thousand. The apparatus has to be portable, easy to operate, even in the hands of relatively unskilled technicians. Here, too, more modern equipment is slowly finding its place. Mobile units equipped with spectroscopic and other recording instruments will be able to scan the stack emissions in a manner vastly superior to that of the old technician with a single probe.

In research and development the evolution of continuous recording instruments has been a great help. No restrictions of cost, size, or operational difficulties should interfere with their application to this work. In these investigations all types of problems typical of atmospheric and source sampling appear. In addition, many new and unpredictable analytical problems arise. The choice of the proper methods requires a good deal of sound judgment and knowledge on the part of the experimenter.

Up to this point we have emphasized the instrumentation necessary in air sampling. More important, however, is the man operating the bubbler or the mass spectrometer. His responsibilities are many. The field man has to choose his sampling location, a most important task, for the old saying is still true that "no analysis is better than the sample taken." There are many more difficulties to be faced by the analyst. Chemical problems are never quite the same from one plant to another, from one research project to another, and the knowledge and understanding of chemistry has to be thorough and broad. In the meantime, many developments have been added from other fields—paramagnetic resonance, infrared, ultraviolet spectroscopy, gas chromatography, flame photometry, and instrument design, including complete electronic systems, to name a few.

Being a key figure in air-pollution control brings with it a considerable responsibility, and often headaches. Enforcement officers, legal talents, and administrative personnel often encounter scientific measurements for the first time. They hear about probable errors, systematic errors, high blanks, instability of reagents, and other interferences. Their exasperation demands, besides competency, great tact and educational talent on the part of the chemist.

Meetings such as the one we are holding this week will help to familiarize us with the different disciplines used in air-pollution studies, and assist us in learning about the difficulties and possibilities in the application of various branches of science and engineering to our particular problems. The personal contacts established here will undoubtedly make a contribution to this end.

Identifying and Measuring Pollutants in Community Atmosphere

Dr. William E. Scott
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The problem of identifying and measuring pollutants in community atmospheres would not be really difficult if we had to deal only with pollutants as discharged to the atmosphere. In most cases these could be identified at or near the source where concentrations are higher. The difficult problem is where we are faced with reactions of these primary pollutants in the atmosphere, particularly, after the primary pollutants have been dispersed, and react to form products which are unknown. I want to stress the unknown character of this complex problem that faces us.

It is very easy to develop methods for identification and quantitative analysis for materials if we suspect they are present in the atmosphere or if we know for sure they are present in the atmosphere. It is only a question then of getting methods that are sufficiently sensitive and so on and, if we know everything that is present, we can guard against interferences and eventually come up with methods that are suitable for an analysis of each of these known constituents.

In the case of the complex situation where we have unknown reaction products, however, we must take a different course. I assume that I was asked to make a few remarks on the status of analytical methods because, at Franklin Institute, we have been concerned since 1953 with determining how known primary gaseous pollutants react at low concentrations in the atmosphere. We have been interested in measuring the rates of reactions when they occur. And we have been, also, interested in determining the nature of the products. In some cases we are dealing with reactions of pollutants in the dark. I mean to imply that sunlight is not necessary to make the reaction proceed.

We have not been concerned with developing standard methods, or methods suitable for large monitoring programs, nor have we been concerned with the development of simple testers, or chemical testers, or chemical methods. Our interest has been primarily in any method which meets certain requirements. The first requirement is that it be a sensitive method. The second requirement is that it provide irrefutable identification of the pollutants in the atmosphere.

I warn you again that we don't know what these might be, so we are facing an unknown situation and, preferably, we want a quantitative method.

I am going to devote most of my remarks to an analysis of the atmosphere for gaseous pollutants—soot, fly ash, solids in general, are not too much of a problem, that is, identifying them and measuring the amounts that we might find distributed in the atmosphere. There are some other problems with respect to aerosols that I will mention a little later. The technique that we chose to analyze unknown atmospheres was Longpath Infrared. We didn't develop this technique; we simply set it up in such a way that we could apply it to studies of reactions of pollutants, both in the laboratory and in the atmosphere.

We have been working since 1956 in that great outdoor air-pollution laboratory known as Los Angeles Basin.

The advantages of infrared spectrometry when you are tackling an unknown complex mixture in the atmosphere are several. One of the main advantages is that infrared absorption techniques do not interfere in any way with the sample. You take the atmosphere into the absorption cell directly. You use no concentration techniques, freezeout, or similar methods. We call infrared spectrometry a "panorama" method because it enables us to examine the mixture for pollutants, materials that we may not even expect to be there. We have no clews; we just take a look at the absorption spectrum and try to identify what we see.

Within limitations, infrared is applicable to the measurement and identification of not only stable pollutants, but also unstable pollutants. We have situations where unstable pollutants have lifetimes of the order of minutes, and it is possible to analyze for these, using infrared techniques.

The disadvantage—and I will be the last one to claim that infrared absorption spectrometry is a cure-all for all of the analytical problems that we might encounter in analyzing the atmosphere—*one* disadvantage is that sometimes we have so many things in the atmosphere or in the particular mixtures we are examining, if we are in the laboratory, that the spectra are exceedingly complex, and we can't make much headway in sorting out the materials that are represented. The sensitivity of infrared equipment as we have used it, and this has been with a single-beam infrared spectrometer, is in the range of 5 to 10 parts per 100 million for materials that absorb rather strongly. There are pollutants, like nitrogen oxide, that are too weak absorbers in the infrared to enable us to identify them in the atmosphere. We have had to resort to other tricks to analyze for these materials. Recently, the infrared technique has undergone some advancement. Franklin Institute has developed twin cells for use with a double-beam infrared spectrometer in an effort to push our sensitivity from a half to, say, one part per hundred million. Commercial equipment is now available and is in the hands of many researchers working on problems of analyzing the atmosphere, and also studying possible reactions of pollutants in the laboratory.

Another method that we have applied, and it is very useful where the infrared absorption spectra are extremely complex, is the use of the new techniques of gas chromatography. You can separate many of these materials, and thus make their identification simpler. Now gas chromatography—some people claim that this is an analytical method in itself. It is or can be made so, if you are dealing with a known situation. But when you apply it to an unknown situation, you definitely have only a separate technique and, as your compounds issue from a chromatographic column, all you know is that you have a compound coming out of this column—you still have the problem of identifying it.

With all of these techniques enabling us to work at concentrations in the parts per hundred-million range, there are still many problems that have not been solved. There are still many things in the atmosphere that have not been identified. It is interesting to note that we have not yet identified in the Los Angeles atmosphere the plant-damaging agent. We have not identified the compound or compounds responsible for eye irritation. We have not identified the aerosol that is formed photochemically in the Los Angeles atmosphere under smog conditions.

The great need in this area, as I see it, is to further refine these methods that we have been using, and only when we are sure that we have a method that can serve as reference, when we are sure we can go out and use this method and get irrefutable results, only then can we really develop simpler analytical methods, less costly analytical methods. I think that improvements will come in sensitivity of infrared equipment. We need improvements in the sensitivity of mass spectrometers. We have a powerful tool for separating pollutants when they are present in low concentrations of parts per hundred million. But we still have the problem, after we separate them, of identifying them, and therefore, we need to push IR and mass spectrometry, where we can, to the point where we shall identify parts per million issuing from our columns.

There are many examples—citing the eye irritant, the plant damaging agent still to be identified—these are only a few of the analytical problems facing us. We know, for example, that we can fumigate certain plants in the laboratory. Middleton and Darley, and others, have demonstrated that you can cause triseptal damage in orchids with a couple parts per billion of, say, ethylene. But when you go out in the field to try to relate what is present in the atmosphere to this damage, you find that you don't have a technique that is sufficiently sensitive. We need to increase the sensitivity of some of these highly refined analytical methods by another factor of ten or a hundred.

Changes in Identity and Quantity of Pollutants, Past, Present, and Future

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Public Health Service, Cincinnati, Ohio

This brief discussion is based upon the following three principal sources:

1. *The Register of Air Analyses as of January 1, 1956.* This is Public Health Service Publication No. 610, and is obtainable from the Superintendent of Documents, Government Printing Office, at a cost of $1.75. It is a finding list of all analyses of the air of the United States available to the public. As such, it excludes the extensive body of data obtained privately and which, for various reasons, is not available to the public. More than 100 different chemically definable individual pollutants or constituents of mixed ones, such as dustfall, are listed for 200 cities in 110 counties of 32 States and territories.

2. *Literature Review of Metropolitan Air Pollutant Concentrations.* This is a report prepared by H. C. Wohlers and G. B. Bell of Stanford Research Institute for the Army Chemical Corps which, with permission of both these agencies, has been reproduced for public distribution by the Air Pollution Program of the Public Health Service and is available without charge while the supply lasts. This publication assembles data from many air analyses and shows how communities in which insufficient air analyses have been made, can develop approximate estimates of their own air-pollution levels.

3. *Air Pollution Measurements of the National Air Sampling Network: Analyses of Suspended Particulates 1953–1957.* This is Public Health Service Publication No. 637 and is obtainable from the Superintendent of Documents, Government Printing Office, at a cost of $2. It incorporates the results of analysis of approximately 10,000 24-hour air particulate samples collected on glass fibre filters, including data on total suspended particulate matter, and acetone or benzene soluble matter, radioactivity, and some 27 other chemical components contained in the particulate.

The More Distant Past

A half century ago, although there were automobiles, diesel engines, municipal incinerators, oil burners, and gas stoves, none was yet a potent factor in producing widespread air pollution. Air pollutants were in general confined to but a few sources. Each major city still had its "noxious trades," productive of malodor. Our economy was producing enough trash to require city dumps, where burning resulted in production of smoke and odors. The new hand-fired steam-electric powerplants were pouring dense smoke into the air. In northern cities, a cold day meant coal smoke from every building in town. Smoke-emitting steam locomotives ran down Main Street. These must have been smoky days, but no record of air quality measurement is available to document this belief. However, barren lands remain as mute testimony to the SO_2 level in the vicinity of some smelters then in operation.

The only kind of measurement that has been made in a consistent manner over any large span of years was dustfall. Data are available on several cities for the past 25 years. What happened during the prior quarter century can only by conjectured. What most likely happened is that as power demand rose, powerplants went from hand-fired to stoker-fired operation, with higher and higher velocity through the grates. Although black smoke from large fuel users became less and less of a problem, grit and cinder emission skyrocketed. Oil burners became more prevalent, decreasing black smoke still more. More and more rail terminals were electrified, so that locomotives were less of a problem in big cities. The automobile was not yet a problem. Pulverized coal firing was introduced. Dust collector development and application lagged behind the rate of increase of grit-producing sources. Thus, at the start of measurement of settleable solids 25 years ago, the grit level was very high indeed. Over the past 25 years, technology has changed to reduce drastically the level of settleable solids in our cities (fig. 1). Dust collectors have been improved and almost universally applied. Natural gas is supplanting oil in

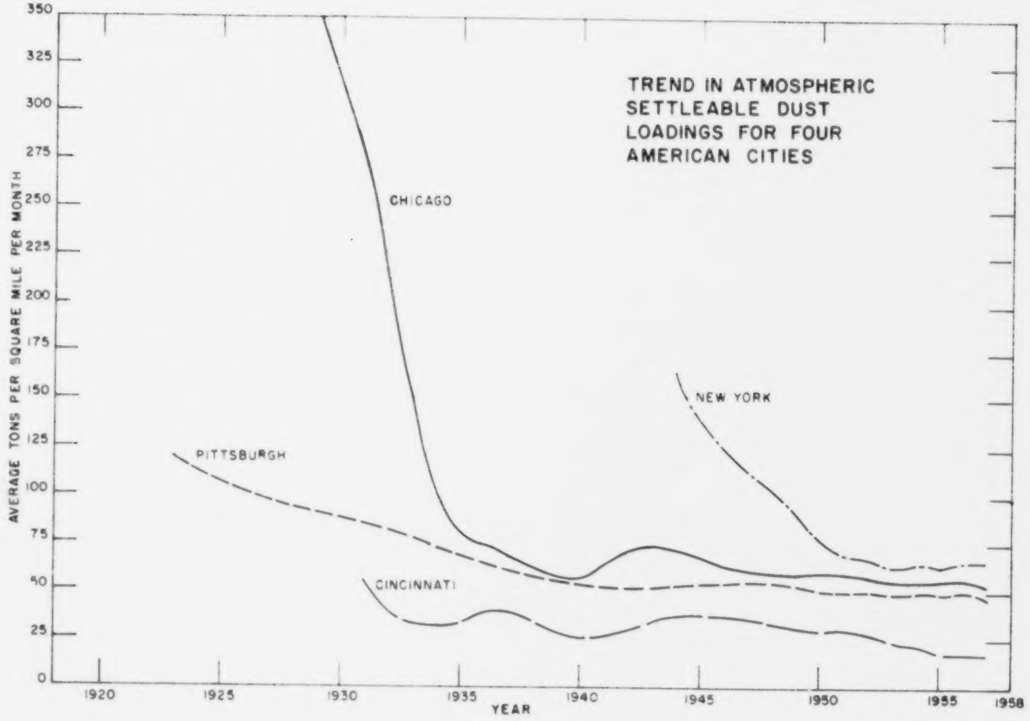
TREND IN ATMOSPHERIC
SETTLEABLE DUST
LOADINGS FOR FOUR
AMERICAN CITIES
AVERAGE TONS PER SQUARE MILE PER MONTH
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1920
1925
1930
1935
1940
1945
1950
1955
1958
YEAR
CHICAGO
PITTSBURGH
NEW YORK
CINCINNATI

FIGURE 1

applications where in earlier years oil supplanted coal. Dense smoke emission has become even more a thing of the past.

The Recent Past

For the last 10 years, we have lived in the era of ever-increasing numbers of sources of individually invisible emissions from automobiles, diesel engines, homes, and factories that in the aggregate load the atmosphere over our cities with a larger pollution burden of suspended solids and gases than at any earlier time. The grit is missing; the visible emissions are few and far between; but because there are more of us, because we live better and have crowded into supercities, the kinds of things in the air are more complex than ever before.

One evidence of this new complexity is that since 1949 we have been measuring, particularly in Los Angeles, pollutants never measured before. Measurements like oxidant (fig. 2) and the complex of gaseous contaminants from which the oxidant forms have been made for such a short time that trends are not as yet apparent. The same might also be said of the measurements of suspended particulate by the National Air Sampling Network, which are available for an even shorter period of time. However, because the data are nationwide in scope, the remainder of this presentation will cover some analyses of the published data in ways somewhat different from those analyses included in the Network publication.

The Present

The nonurban sampling portion of the network has been operating on a systematic basis only since 1957, during which time about 400 samples have been taken, uniformly distributed among all classes of such sites. During 1954, 1955, and 1956, about 150 samples were taken, but only in forest and farmland sites. Analysis of the quantity of supended particulate matter measured at all these sites (fig. 3) discloses a different pattern for coastal and inland sites. Coastal sites in general have a smaller range between high and low values than do the inland sites. The low values do not get as low at coastal sites as they do at inland sites. This is most likely because salt from sea sprays is always present in coastal air in sufficient quantity to set a floor below which suspended particulate matter cannot go. Among the three seacoasts—Atlantic, Pacific, and Gulf—differences are quite small.

Larger differences are apparent among the inland sites. Desert air is the cleanest; mountain and forest air is about twice as polluted with particulate matter; and that of farmland and the Great Lakes shores about three times as dirty. The explanation that comes first to mind is that the desert stations are remote from man's activities, that the desert surface is not manually disturbed, and that the major source of pollutants is dust resuspended by wind. Forest sites would be expected to have more pollution sources: tree and plant pollens, leaves and windblown fragments of trees and plants, forest fires, and man-generated pollutants from nearby homes or cities. Farmland sites would be expected to show even greater pollution due to closer proximity to man and his cities, and the generation of pollutants due to

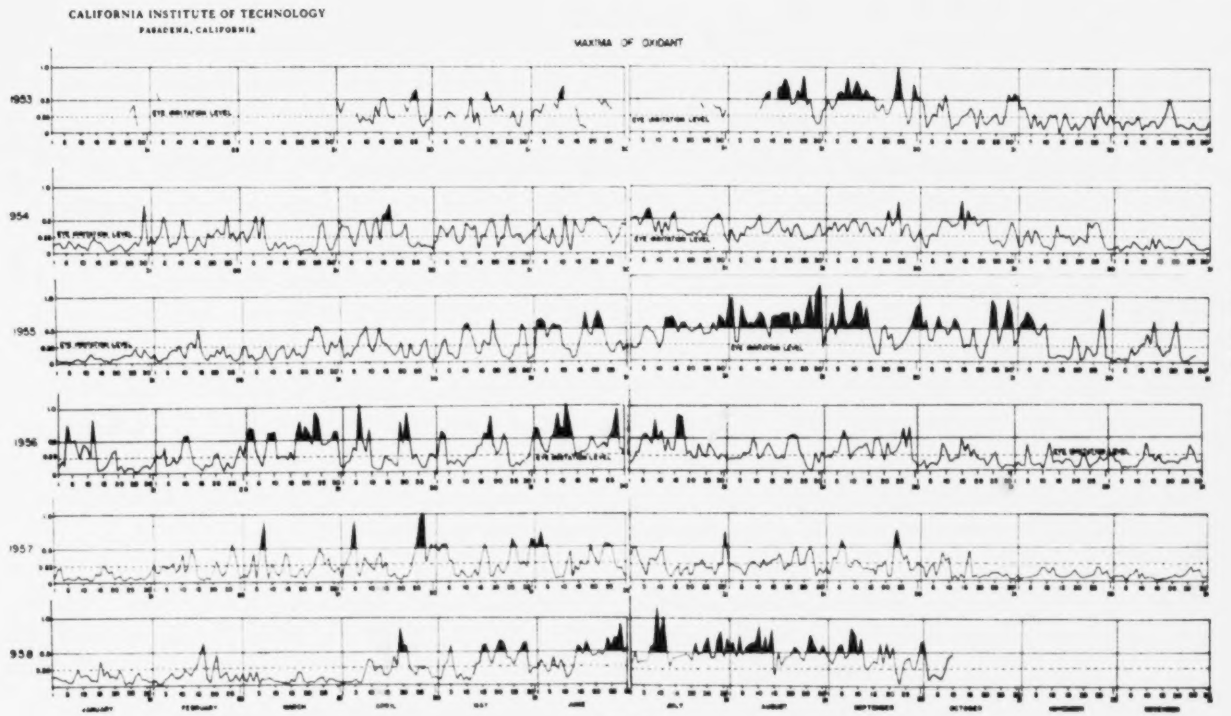
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA
MAXIMA OF OXIDANT
PARTS PER MILLION OXIDANT (PPM)
1953
1954
1955
1956
1957
1958
1.0
0.5
0.25
0
EYE IRRITATION LEVEL
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIGURE 2

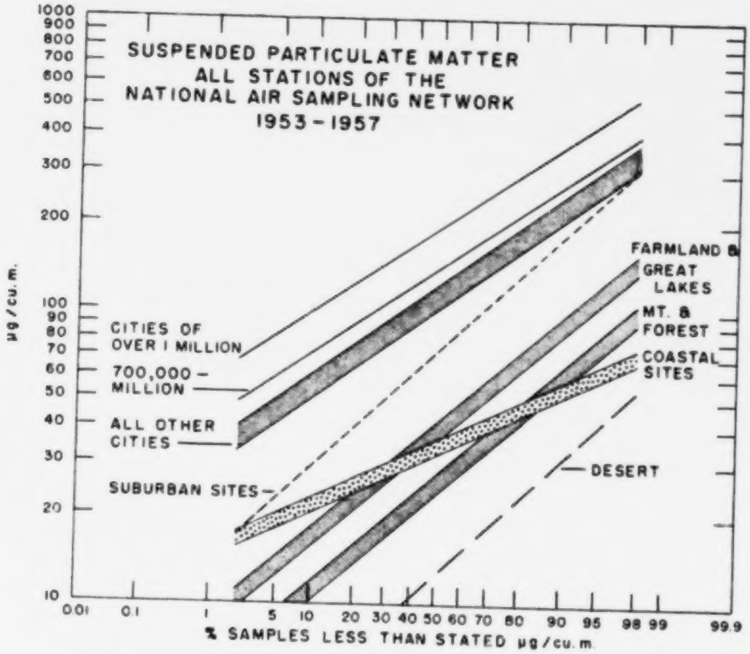

FIGURE 3

working the ground and exposing unsodded ground to the wind. In the Great Lakes coastal area, it is impossible to select a lake front site very far from farmland or urban influences. Because of these latter factors, high values at inland nonurban sites are considerably higher than high values reported from coastal sites.

Our Big Cities

Although there are these differences in pollution at nonurban sites, even the dirtiest of nonurban site categories is much cleaner than any of the urban or suburban site categories. It is much easier to differentiate between the quite clean nonurban site categories than between most of the different population class categories of urban sites. Urban data on which this analysis is based come from about 9,500 urban samples collected between 1953 and 1957 inclusive. In the massed 1953–57 data, it was almost impossible to find major differences in the several categories of cities between 10,000 and 700,000 population. These 117 cities as a group are cleaner than the 11 cities of over 700,000 population, and are dirtier than their own surburbs. The mixing of pre-1957 data (when the network was less homogeneous than during 1957 and 1958) with 1957 data may have masked effects of population difference that will show up later when 1957 and 1958 data alone are compared on a population category basis. On comparing all the urban data with all the nonurban data (fig. 4), the fact

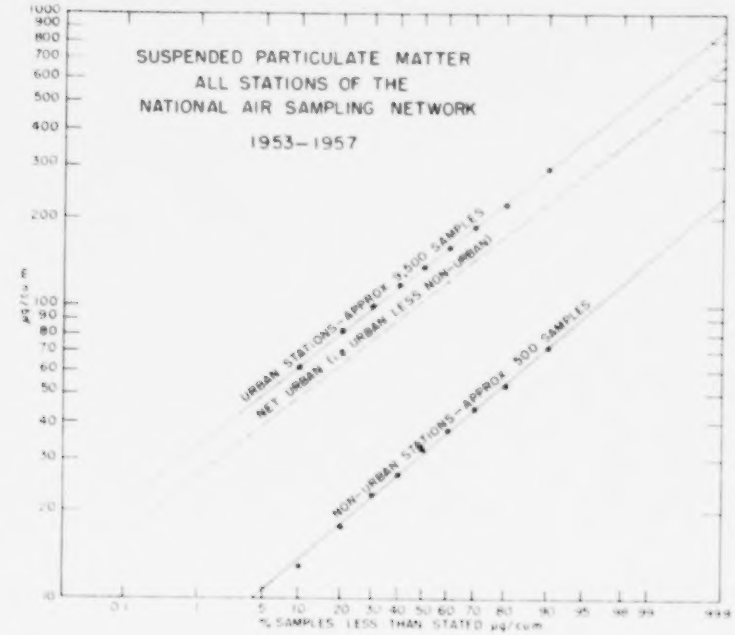

FIGURE 4

that stands out is that urban areas in the United States are five times as polluted as nonurban areas.

The Future

Since these data were taken over a 4-year period, it should show some evidence of whether the Nation's air is getting cleaner or dirtier. What it does show is a yes and then-again-no kind of answer to this question. Firstly, the nonurban data before 1957 were too meager and limited in category to be used to establish trend in background levels. Without knowledge of changes in background level from 1954 to 1957, urban data are difficult to compare. The urban data for each of the ensuing years encompass a different combination of cities and sites. However, the data (fig. 5) seem to show that American cities became dirtier from 1954 through 1956, but cleaned up somewhat during 1957. Actually, we do not believe that the apparent improvement in 1957 is real, but rather that it is due to a change in sampling procedure initiated at the start of 1957. At that time the filters were provided with a form of shelter that prevents particles in the "cinder" class that are not truly "suspended" particulate matter from getting into the sample. To some extent this entry was possible with earlier shelters. Therefore our general conclusion is that despite the apparent reversal of trend in 1957, American cities are getting dirtier. Whether this statement can be verified by 1958 and 1959 data on a much more homogeneous set of sampling sites remains to be seen.

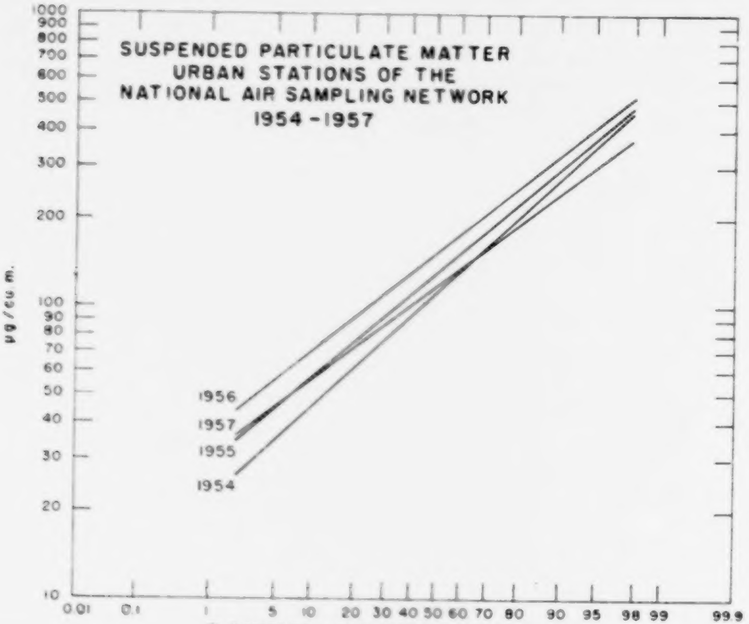

FIGURE 5

The Cure

To prognosticate future trends of pollution levels in the U.S.A., one must make certain assumptions, one of the most important of which is the relative contribution of industry and the general public to these levels. A rough test of this relationship is the comparison of pollution on Sundays with weekdays (fig. 6). If the Sunday pollution levels were much lower than weekday levels, it might be reasoned that spectacular reduction of pollution by industry will reverse the present trend towards dirtier air. If the difference between weekday and Sunday pollution is small, it may be reasoned that it is the public in all its activities that has to do the real cleanup and that it will be much tougher sledding to reverse the dirtying trend. Unfortunately, this latter seems to be the case as far as an analysis of the 1957 network data will reveal.

More data and more penetrating analysis may well cause us to sing a different tune in the years to come. However, this is the way we see it from the analysis made to date of the available data. By limiting this discussion to total settled and suspended solids, we have obviously skimmed the surface and left many questions unanswered. However, what more can one hope to accomplish in just a 15-minute presentation!

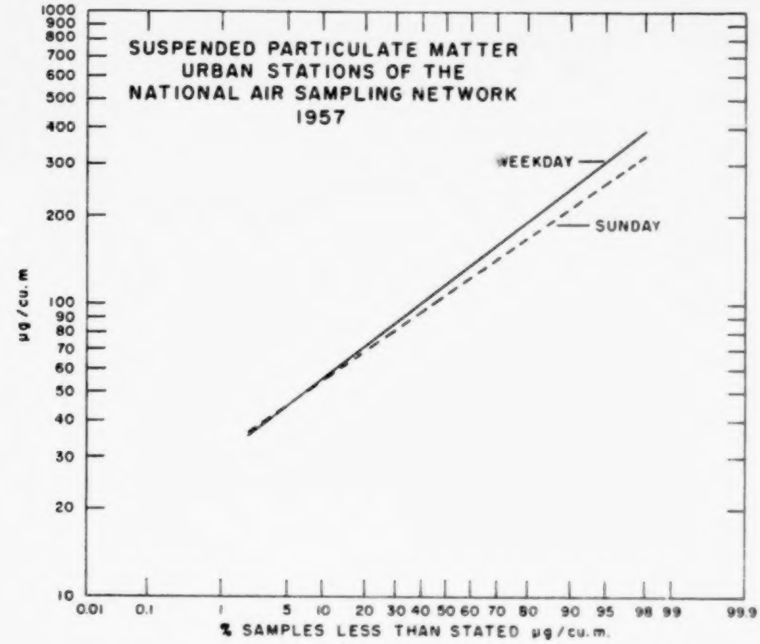

FIGURE 6

Are Sampling and Analysis Techniques Adequate for Today's Needs?

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A fundamental function in the control of air pollution is the determination of the kind and amount of air contaminants. The basis for establishment of criteria as to the relative amount of pollution in any atmosphere, urban or rural, depends upon proper sampling and analysis of the sample. One may well ask again: are sampling and analysis techniques adequate for today's needs in air-pollution control? In some respects they are, in most respects they are not. Delineation of the problems involved will clarify the brief answer. Methods and sampling techniques for the determination of air pollutants can be placed into several major categories:

1. Suspended Particulate Matter
2. Settled Particulate Matter
3. Gaseous and Vapor Pollutants
4. Analysis of Pollutants at the Source

5. Detection of Pollution Sources

Let us discuss each one of these major categories of air-pollution control sampling and analysis in somewhat greater detail.

1. Suspended Particulate Matter

There are various techniques available for the sampling and analysis of suspended particulate matter. Briefly, these can be classified as—

a. Filtration Methods
b. Electrolytic Precipitation
c. Thermal Precipitation
d. Impingement

a. *Filtration Methods.* Of the aforementioned methods those employing filtration are most widely utilized. These filtration methods may be further classified into those known as—

(1) High Volume Samplers
(2) Automatic-Filtering Paper Samplers
(3) Membrane Filter Samplers
(4) Other Filter Samplers

(1) *High Volume Samplers.* Various high volume samplers are available. They are designed in general to sample at rates of approximately 60 cfm. The filter, usually a glass fiber web, is weighed before and after sampling and the sampling is carried on for 24 hours.

A considerable amount of work has been done with such samplers. For instance, they form the basis of the National Air Sampling Network and are presently being used by the New York State Sampling Network. These devices have certain advantages, namely, those of ease of emplacement and sampling for long periods of time (24 hours), but they have several marked disadvantages, for example, the glass filter web introduces unnecessary complications in the subsequent chemical analysis, the peak of the diurnal pollution is missed in a 24-hour average, and unless the sampling is carried on on a daily basis any day or period of high pollution or any day or period of low pollution may be missed completely.

The actual methods for analysis of such samples have received relatively intensive investigation. Some of these methods, such as those for total suspended particulate matter, total benzene- or acetone-extractable matter, have been relatively standardized, but little has been done on analysis of the individual solid organic components. Since some of these, namely, the polynuclear hydrocarbons, are known to be carcinogenic agents, this is an important problem that should be solved.

(2) *Automatic-Filter Paper Samplers.* A second major group of sampling devices for suspended particulate matter are the automatic filter paper samplers. These devices generally comprise a pump which draws the air through a filter paper tape at a given rate. The decrease in light transmission or the decrease in light reflectance of the spot or trace made by these samplers is measured. The early samplers had the disadvantages that the amount of the sample was too small to lend itself to chemical analyses for most things even with

ultramicro methods but improvements in the type of paper used, such as nylon reenforced membrane filter tape and radiochemical techniques, will permit far greater utilization of such sampling methods. It must be stressed, however, that the use of such improved modifications has only begun and a considerable amount of work remains to be performed for their standardization.

(3) *Membrane Filter.* The use of membrane filter techniques is being expanded. Dust count samples can be taken and the dust counted either directly or by dissolving the filters in a solvent such as acetone. As in the instance of the automatic filter paper samplers, additional development of ultramicro and radio-chemical techniques are necessary.

(4) *Other Filter Paper Methods.* Filtration methods employing filters for quantitative analysis have been developed. These papers have the advantage that they can be used for taking suspended particulate matter samples for periods of an hour or two and subsequently can be analyzed chemically by wet methods. They lend themselves to determination of diurnal peak concentrations. Their major disadvantage is that they require considerable manpower for the analytical work.

b. *Electrolytic Precipitation.* Electrolytic precipitation methods for dust have been very well developed in industrial hygiene work. They have not had as much exploitation in air-pollution control work other than at source of pollution investigations. Since such methods can at times enable one to obtain the sample without intervention of a filter, that is, the sample can be obtained in its original state, they have value.

c. *Thermal Precipitation.* Thermal precipitation methods also enable sampling without change of the original material. Because of the smallness of the sampling and the apparent difficulty of the techniques, they have not had much exploitation.

d. *Impingement.* The use of impingement for sampling is one of the major methods in industrial hygiene work and there has been considerable use of such methods in air-pollution control analyses, particularly with automatic sequence samplers. Most of these, however, have been methods used for the sampling of gaseous and vapor air contaminants. Since the Greenburg-Smith impinger and its modifications are considered the sampling vessel of choice for dust counting in industrial hygiene work, there has been some use of such vessels for sampling of suspended particulate matter with respect to air-pollution control work. It is difficult, however, to trap and see particles less than one micron by such wet impinger methods, and consequently more interest has been displayed in the use of membrane filters for dust counting.

2. Settled Particulate Matter

For many years the major and virtually the only method used for evaluation of air pollution was that of determining settled particulate matter in which the principle of deposition is employed. Such methods generally are known as sootfall or dustfall methods. The Air Pollution Control Association has adopted a standard method for the determination of sootfall and the American Society for Testing Materials is presently considering a tentative standard method.

It is possible that more analyses of sootfall or dustfall are made in more cities and communities than any other type of analysis; nevertheless there is a wide variety of sampling methods and a relatively nonuniform method of recording results. Thus, in Great Britain a wide funnel-like arrangement is used to catch the fallen dust which is washed into a bottle below the funnel by the rain. In such collection devices the winds may blow in and blow out the dust. In Toronto an analogous type of collection vessel is used; in Los Angeles, and formerly in New York, wide-mouth glass jars similar to those for holding Bohemian-style pickles are used. New York City adopted a polyethylene type jar in 1958.

Deposition methods as exemplified by the sootfall method have value in that they have been used for longer periods of time than any other method, and that one can conclude, with a relative degree of certainty, that if the amount of soot or dust falling into a jar emplaced in the same location for many years increases significantly the pollution is actually increasing.

3. Gaseous and Vapor Pollutants

If one were to consider only the methods and data obtained by analyses of suspended particulate matter and settled particulate matter, one might be tempted to conclude that considerable progress had been made in sampling and analysis in air-pollution control work. It is when one considers the paucity of good methods, simple instruments, and rapid techniques available for the determination of gaseous and vapor pollutants of the atmosphere that one realizes the grave need for further and intensive work in this field. Both chemical and instrumental methods have been well developed for the determination of micro amounts of sulfur dioxide in the air. Adequate chemical methods are available for ammonia and for aldehydes. Both chemical and infrared instrumental methods are also available for the determination of carbon monoxide in air. Only recently have good methods become available for the determination of nitrogen dioxide in the part per million range and for phenol and hydrogen sulfide in the part per billion range in air.

There is a serious gap, however, in the methods available for the determination of oxidants and ozone in air. While a number of methods have been published and are used, not one of these is really adequate. A major difficulty in this respect is that there is no good way of obtaining standard ozone concentrations so that standard curves cannot be prepared. A similar situation exists with respect to total nitrogen oxides.

Without doubt a major deficiency in the analysis of air contaminants is the lack of specific methods for organic compounds in the air. Mention has already been made of methods for aldehydes and another for phenol. More recently a method for ultramicro determination of acetylene (using the well known Ilosvay cupric acetylide reaction) has been developed. There are also available some methods for unusual air contaminants such as the insecticides, parathion, and DDT, and in this connection one might well mention the methods available for the "poison" war gases.

The facts are, however, that the present-day normal urban atmosphere contains a wide variety of organic vapors in minute concentrations for which adequate methods of sampling and analysis have not been developed. Samples are obtained at times by condensation, that is, freezeout techniques but such samples are so complex in composition that grave difficulty is encountered in their analysis. The reason for this complexity is that the exhaust gases from motor vehicles comprise a significant portion of this urban atmosphere. Such atmospheres are commonly referred to as containing "normal traffic gas." Instrumental methods of analysis employing both mass spectrography and ultraviolet techniques have merely emphasized the complexity of this problem, for they are of limited value. More recently the development of infrared instruments and the methods of vapor-phase or gas chromatography appear to have great promise but only a start has been made in these fields. It is to be noted also that since there is often a time lag in the reactions or recorders of most instruments used in air-pollution analyses, instantaneous concentrations are not measured; most instruments require trained operators; and some instruments are very expensive. These factors limit the usefulness of instrumental methods of sampling and analysis.

4. Analysis of Pollutants at the Source

In order to control air pollution, it is necessary not only to know how much pollution there is but also where it comes from and how to abate it. As a consequence of the analytical interest in how to abate the pollution, it is necessary to have methods to enable us to evaluate the efficiency of any given abatement device. One can group all of the methods for the determination of emissions from chimneys, incinerators, stacks, flues, vents, etc., whether from industrial, commercial, residential, etc., as stack sampling and analysis methods. One can group the emissions from automobiles, trucks, Diesel engines, etc. as motor vehicle exhaust gas emissions.

a. *Stack Sampling.* Methods for sampling of stacks have been standardized by the American Society of Mechanical Engineers. Such methods, however, are difficult to perform, require a skilled staff, are expensive, and time consuming. While the methods themselves have been well defined for many objectives, simpler and more rapid techniques would be of considerable value in air-pollution control. Such methods have to be developed.

b. *Motor Vehicle Exhaust Gases.* Methods are available for the analysis of the gross composition of motor vehicle exhaust gases. These are often performed by Orsat or equivalent techniques. Methods are available for the chemical determination of aldehydes, nitrogen oxides, sulfur dioxide, lead, and carbon monoxide in motor vehicle exhaust gases but the present state of analysis for hydrocarbons and other organic compounds in automobile exhaust gas leaves much to be desired. One problem that requires solution is a simple method for the determination of the amount (volume or weight) of exhaust gas for motor vehicles.

5. Detection of Pollution Sources

The detection of pollution sources is an important facet of air-pollution sampling and analysis. Methods based on the detection of (a) odorous compounds, (b) characteristic substances, and (c) fluorescent tracers were the most common. More recently the use of dyes and substances which could serve for induced radioactivity have been employed. All of these variations require more intensive investigation.

6. Summary

The major categories of sampling and analysis used in air-pollution control work have been briefly reviewed. The methods used for determination and characterization of suspended particulate matter and deposited particulate matter have been investigated with a fair degree of thoroughness although much remains to be done in these fields. The present state of sampling and analysis for gaseous and vapor air contaminants, both chemical and instrumental, leaves much to be desired. Here a considerable amount of work and investigation remains to be done. This lack of good methods also extends to that section of air-pollution control analyses dealing with pollutants at the source and with source of pollution investigations.

Are Monitoring Programs Adequate?

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The question of the adequacy of monitoring programs in the United States is an important one. Inadequate air monitoring can permit worsening of conditions to the point where another Donora could occur. This is a loss we can scarcely afford. Monitoring, however, is an extremely expensive operation, and superfluous or ill-planned monitoring also is a serious waste. Thus there is presumably at any given time an optimum level of monitoring defined by the balance of need for information on the state of our air on the one hand, and the cost of obtaining the information on the other. It seems reasonable to assume that our "need-to-know" will increase for some time to come. The cost of obtaining this information, however, is already great, certainly of the order of $1.5 million per year. Yet it is easy to list information not presently available.

For purposes of this paper, the term "monitoring" will be taken to mean continuing routine measurements of air quality, as distinguished from investigations of a small number of samples for research purposes. For simplicity, pollen counts and radiological measurements have been excluded from consideration.

As an indication of the status of monitoring programs in the United States, an examination was made of the contents of the *Register of Air Pollution Analyses* published recently by the Public Health Service. This publication lists all known instances of air monitoring, as well as some nonroutine measurements, up to January 1, 1956. It does not, of course, list the considerable volume of monitoring done by industry for its own protection. However, this work has never been made available to the scientific community or the public, and consequently, for our purposes, might as well never have been done. This body of data will therefore be ignored in the rest of the discussion.

It has been said that roughly 10,000 communities in the United States have some sort of air-pollution problem. The *Register* lists 194 communities in which measurements were actually made prior to 1956. These were located in 29 States, the District of Columbia, and the Territories of Alaska and Hawaii. Thus, 19 States had no recorded data. Furthermore, nine States were represented by only a single city, and two States by two cities each. Two States accounted for 94 of the 194 communities (48%). And in only 111 communities was *any* continuing program indicated.

Another breakdown of available data from the *Register* shows that 150 urban areas were measuring some aspect of particulate pollution, while 84 measured gaseous pollutions. Thus only in 40 communities (21%) were data available both for gases and particulates, and in many of these the measurements were not simultaneous.

It must be admitted that these data include only 6 months of the increased activity brought about by the passage of Public Law 159, 84th Congress. However, they do comprise *all* available work done up to the passage of that law, and probably represent a total expenditure of close to a million dollars. It seems unlikely that the total number of cities for which information of some sort is available can have more than tripled; a figure of around 400 communities is probably more realistic.

We have said that the current expenditure for monitoring is about $1.5 million per year. If this expenditure is providing information concerning 400 communities, and if there are 10,000 communities with air-pollution problems, it can be seen that the cost of intensive country-wide monitoring would be impossibly large.

It is not unlikely that continual sampling and analysis of the air of 10,000 communities constitutes too much monitoring from the scientific, as well as the economic standpoint. There is one possible benefit: 10,000 or more samplers in continuous operation might remove so much material from the air as to decrease pollution. Seriously, however, our present state of knowledge is such that many analyses now made are never interpreted or made use of in any way.

Air-pollution monitoring, like all other phases of air-pollution work, is directed toward one end only: the reduction of pollution. Within this context, monitoring may serve four functions: it may signal the existence of pollution; it may identify the source of pollution; it may indicate trends; and it may serve to warn of air pollution emergencies.

When the functions of monitoring are set forth in this fashion, it becomes obvious that there is no simple formula for the amount of monitoring which is right for a given community at a given time. The amount of detailed knowledge needed of the nature and concentration of pollutants present in the community atmosphere varies with location and time. Since monitoring has been defined as a continuing program, it is by its nature somewhat inflexible in the amount of information it affords, and is often less well suited to community needs than a well executed program of spot sampling and analysis. Let us consider the functions of monitoring one by one and see, not what monitoring *may* do, but what it can do best.

However subtle and indetectable individual pollutants may be, the overall complex of pollution is very easily detected. We are all aware of malodors, excessive dust, smarting eyes, decreased visibility, or other symptoms of unclean air. Hence, so far as detecting pollution, monitoring can only quantitate what we already know—that pollution is there.

Data obtained by air analyses can, under appropriate circumstances, yield information on the source of pollution. However, to set up a full monitoring program for the purpose resembles using cannon to shoot sparrows. One clever scientist should be able to solve the greatest percentage of such problems in a few days of suitable weather. The problems of this sort not susceptible to solution in this manner cannot be solved by monitoring either. It is certainly futile to perform analyses year after year showing the presence of pollution from a given source, if nothing is being done to control the emissions from that source. The only product of such an operation is another paper in the already overcrowded technical literature.

Monitoring can yield numbers related to the concentration of the pollutants present, and these numbers may be interpreted to show trends. A long term downward trend may be interpreted in terms of success in the control of emissions to the atmosphere. Now, trends can only be shown by continuing measurements; consequently, the demonstration of trends is peculiarly the province of monitoring. However, consider one actual case—a small town deluged by ashes from a large sawdust incinerator. A few months work gave unequivocal evidence that the fault lay in one specific source. Controls were installed on that source; dustfall dropped to a hundredth of its previous value. Is a continuing program of analyses necessary to show that the reduction was precisely 99 percent? There is, then, a degree of judgment involved as to whether a community situation warrants continuing monitoring, or can be solved and written off, and the money and manpower moved elsewhere to tackle other problems.

Finally, we come to monitoring as a pollution disaster warning system. This is probably the most argumentative area to be considered. Certainly, if there is reasonable probability of disaster, it is criminal negligence to fail to provide early warning against it. The question to be settled, then, is the definition of "reasonable probability." A few years, at most, of monitoring can indicate the *numerical* probability of a given concentration of pollutants. But can a continued full-scale analysis program be justified solely for a warning which will be sounded only once a century? Probably the occurrence of dangerous levels at least every 10 years, or good evidence of increase in pollution toward this level, would be necessary to make a warning system for its own sake defensible. Even in these cases, research or experience may show that only a single substance needs to be monitored for warning purposes.

The principal justification, then, for continual monitoring must be the determination of air-pollution trends in cases of sufficient complexity that these trends are not obvious. In cases where disaster can reasonably be expected, monitoring of a simple sort can serve as an alarm, though it is no substitute for remedial action. Any other information arising from monitoring operations must be regarded as a byproduct, not an end.

There is a form of air quality measurement which can be used in many situations which does not quite fit our original definition of monitoring. This is routine measurement over a finite period of time sufficient to establish base levels. These levels may then be used for comparison with spot measurements taken subsequently. For this purpose, such 1-year studies can serve very well.

If our present monitoring program is measured against the foregoing, we find that our initial question, "Are our monitoring programs adequate?" must be answered with a firm "No." This is in fact a double no; some areas are overmonitored and/or wrongly monitored; one heavily monitored area has recently greatly decreased its staff and equipment for this purpose. Many communities, on the other hand, with equally serious and complex problems lack facilities for even the most cursory examination.

What, then, do we need? We need a hard look at existing programs of routine air analysis, to define their aims and to see if they represent the best and most economical means of achieving these aims. In a few cases there is room for doubt whether any aim exists. We need to look at pollution problems across the country to find those situations in which monitoring is needed. We need an enlightened public, which it is hoped this conference can help provide, which can understand why monitoring must be done and what it must cost; the public must also understand that monitoring is not a panacea, and that it is inapplicable in many situations. Finally, we need research. We need research on analytical methods and tools. A few millions spent now on techniques to be used both for monitoring and for spot checks of pollutants can make such monitoring as must be done less expensive, and may well avert the need for its use. We need research on control equipment to decrease emissions to the atmosphere. We need research to show what pollutants cause the effect we all know and complain about. These will all cost money, quite a lot of money. But the ultimate savings should be many times the cost of research.

Can Standard Methods Be Established for Identifying and Measuring Air Pollutants?

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The objective of any air-pollution survey is to obtain data that can be used to answer questions for a great many reasons. Data may be collected to determine the physical and health effects of pollution, to survey conditions attributable to a single source of pollution, to identify a single contaminant, to determine the efficiency of control measures, and to plan abatement programs for communities or industrial complexes.

The scope and purpose of the investigations determines the type of information which must be collected while the usefulness of the data for purposes of interpretation depends upon many factors. Consideration must be given to the types and properties of the pollutants, the number of samples and their representativeness, the number of the sampling stations and their locations, the accuracy, sensitivity, and specificity of the analytical methods, and the fluctuations in concentration which occur as a result of changes in the seasons and of meteorological conditions.

Generally speaking, the more data available, the better will be the test. However, since the collection of data, particularly in a systematic manner over a long period of time, is a costly process, a clear understanding of the goal to be reached may frequently result in a considerable reduction in effort. Thus, when damage or pollution can be related to the presence of a single contaminant, only a few samples over a period of several days or at most a few weeks, will yield data suitable for pinpointing the source of the pollution, or for determining the effectiveness of a control measure. (Examples of this approach include the determination of amounts of smoke, fly ash, and sulfur dioxide in the vicinity of large coal-burning power stations, and the fluoride content of the air and of the vegetation near plants processing fluoriferous material.)

In surveys dealing with effects due to the pollution of the atmosphere of metropolitan areas, the collection of useful data becomes a difficult task because of the complexity of the air-pollution problems. These problems are dynamic in character since they undergo continual change with the types of fuels being used and with the changes and expansions in the activities in metropolitan areas. Moreover, the pollution differs for different areas and the problems vary from community to community. In order to gauge the magnitude of a community problem or to study the effects of changing conditions, systematic records in a number of areas over several years are usually required. These data should not only portray the average concentrations; they should also indicate the peak concentrations and the duration of their occurrence, since the intense pollution, no matter how fleeting, is likely to give rise to the most complaints and the worst damage.

Having, therefore, satisfied ourselves that the findings are representative of the pollution problem in the area, interpretation of the data is based primarily on experience and on comparison with findings in other areas. The degree of pollution is judged by the similarities and differences between values and a knowledge of the levels required to cause certain responses. Among the examples may be included comparisons of the amounts of sootfall during different seasons of the year; before and after concentrations as a result of changes in process or the installation of control equipment; the amounts of the sootfall in different communities; comparisons of data collected during different years; and finally, the findings for certain pollutants may be compared to the levels which are known to cause eye irritation, corrode metal, damage vegetation, or cause injury to farm animals by being deposited on the vegetation.

Data may also be evaluated by statistical means. While these mathematical methods cannot be described in this brief discussion, it should be noted that the statistical methods are important tools for determining the significance of the differences between values and for judging the probability of the occurrence of nuisance or toxic levels of pollutants.

Objective Standards on Contaminants

The need for standards on air contaminants is obvious. The setting however, of objective standards of pollution implies that objective criteria for establishing the standards are available. In this connection it is important to note that the criteria differ with the problems, which may be considered as falling into four general categories:

1. Pollution having nuisance properties.
2. Pollution causing corrosion or deterioration of material.
3. Pollution affecting plant life or causing animal damage.
4. Pollution that affects human health.

In our discussion of criteria of damage, a distinction must be made between acute and chronic effects. Acute effects result from exposure to abnormally high concentrations, usually of a known deleterious agent emitted into the air as the result of an industrial accident. The incident will be of brief duration and the damage is well defined and easily recognized. The chronic effects arising from long continuous exposures to low concentrations of pollutants on the other hand are difficult to determine and are so controversial that reliable criteria of damage are lacking except for a few pollutants which historically have been associated with certain types of damage which are seen on structures and in vegetation.

Safe levels of specific gases or vapors that cause corrosion or deterioration of material can be formulated by observing the effects caused by the contaminants in question in field or laboratory work. Standards for pollutants that soil property, possess obnoxious odors, or cause eye irritation can be set from the esthetic point of view usually on the basis of the most practical sensitive index. A good deal of information is available concerning the levels of concentration at which such materials as chlorine, hydrogen fluoride, sulfur dioxide, other acid gases, or ozone affect vegetation, so that safe levels for the protection of vegetation can be or have been formulated. Since there are numerous examples of damage to livestock by the emission of fluoride and lead and arsenic compounds, standards for these may also be set quite easily.

When the public health aspects of air pollution are considered, we find, unfortunately, that we have very little information which can be used to demonstrate the cause and effect relationship of air pollution. In none of the historic major acute episodes of air pollution has it been possible to identify a single pollutant as the cause of the hygienic effects. Rather, it is postulated that the injury was produced by a combination of irritating materials acting synergistically, but none of which could have been the responsible agent by itself. Since no single agent can be identified as responsible for the injury which has been observed to occur, there is no justification for setting standards for specific contaminants at the present time.

Standards of pollution based on health effects will be developed in time, but only after sufficient information concerning the disabling effects of pollutants under given atmospheric conditions is obtained. Such standards could develop from the consideration of a multiple prediction equation which would take into account the average concentrations for a number of pollutants, along with the meteorological conditions required to produce a selected response in excess of that occurring under normal conditions. With such an equation it would then be practical to assay the contribution of certain individual contaminants to a specific increase in the incidence of selected symptoms in relation to the presence of other types of pollution and atmospheric conditions. As you may realize, this will be a tremendous undertaking that will require an intensive and vigorous program of research which would include the collection of extensive epidemiological and physiological data, as well as the continuous monitoring of the air for several pollutants and meteorological conditions.

Standard Analytical Methods

The use of standard methods of analysis will be possible when there is general agreement as to the nature and type of the materials to be looked for in the atmosphere. However, we are far from such an agreement since the philosophy and techniques of air sampling and analysis vary with the specific problem, the special interests of the investigator, and the dynamic nature of the air-pollution problems. As a result, a great many methods for determining specific pollutants, radicals, or functional groups have been developed but these have not been critically reviewed to determine their specificity or other limitations. Since such information is necessary in order to select a standard method, the prospect for the availability of standard methods in the near future, except for a few contaminants historically associated with the use of solid fuels, is not bright. The shortcomings have been acknowledged by the fact that a number of scientific groups have taken steps to obtain the information which is required. However, because of the complexity of community air-pollution problems, rapid progress in the development of standard methods should not be expected although it is encouraging that some active work in this field is under way.

In England there has been some form of standardization since 1912, when an Advisory Committee on Atmospheric Pollution was set up. This committee, now in the Department of Scientific Industrial Research (D.S.I.R.) has had the cooperation of about 180 local authorities, who make regular measurements in their areas by methods prescribed by the Department. These measurements, mainly of dustfall and sulfur dioxide by the lead-peroxide candle method, give indices of pollution measurements which are suitable for establishing differences in pollution between English cities, but the findings are difficult to relate to quantitative data based on the use of more precise methods.

As a result of the tremendous advances in analytical techniques, particularly in the development of instrumental methods, which have occurred since 1948 a number of agencies in this country have undertaken the task of studying the various analytic methods and proposing tentative standard procedures for determining the concentrations of air pollutants. The Air Pollution Control Association has examined techniques for determining dust- or soot-fall and has recommended equipment and procedures which are being accepted as standard. The American Society for Testing Materials, through its Committee D-22 on Methods of Atmospheric Sampling and Analysis, is engaged in an extensive investigation of sampling and analytical procedures for air-pollution work. Since the organization of this committee in

1951, tentative procedures have been adopted for the continuous recording of sulfur dioxide, for the determination of fluoride and oxides of nitrogen, for measuring odors in the atmosphere, and for sampling the atmosphere for gases and particulate matter. The committee has also prepared a list of tentative definitions of terms relating to atmospheric sampling and analysis in the hope of standardizing terms and developing a common background for understanding the problems caused by polluted air. The various study groups of this committee currently are examining methods for collecting and measuring particulate matter and the use of various instrumental methods for the continuous recording of the concentrations of such contaminants as sulfur dioxide, nitric oxide, nitrogen dioxide, ozone, hydrocarbons, and carbon monoxide. As may be seen, the list includes most of the materials which at present are receiving the attention of research groups and it can be expected to expand gradually as the importance of other materials in the air is demonstrated by the research under way in various sections of the country.

Effects of Topographic and Meteorological Conditions on Distribution of Air Pollutants

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Today, I would like to divide this brief discussion, if I have time, into two sections: first, a very general review of meteorology in relation to distribution of air contaminants; and second, a brief list of suggested areas in which meteorological investigations could be pressed more energetically.

With regard to the weather elements we are concerned with, wind, of course, is all-important. First, wind direction. This should be obvious: if the wind comes from the north the pollution should travel to the south. But again, we have to be a little careful there where we measure the wind. Wind varies with height quite markedly, and we want to be sure that we are measuring the wind proximity at the level at which the pollution is carried downwind. So even the wind direction isn't as simple as it might appear to be at first sight.

With regard to wind speed, which is the next of these wind factors, there are three effects that we want to consider: first, the general one that ventilation, by and large, is proportional to wind speed. If the wind speed is twice as great, that means that the volume of air into which, say, a given contaminant per second can flow is twice as great as when it has half the value.

Another important factor which is sometimes overlooked in wind speed is its effect on the aerodynamic downwash. Especially near large electric generating power stations, contaminants may be carried to the ground by this downwash if the wind is fairly strong. A characteristic wind speed at which the aerodynamic downwash will carry contaminants to the surface may be 15 to 20 miles per hour.

And thirdly, the wind speed produces mechanical turbulence. This leads us directly into the third wind parameter we are concerned with, that is, wind turbulence. This is the more or less random irregular change in wind speed and direction which is such an effective mixing agency in the atmosphere. If you think of a source of pollution, say a point source, and you think of the wind fluctuating in direction over a period of time—in one instance the wind will carry, say, gas or smoke in one direction; a few seconds later or minutes later, in another direction. And though these are grouped around a mean direction, nevertheless, this produces a very marked mixing in the atmosphere. It is well to emphasize here that this mixing is the primary diffusing agency in the atmosphere. For example, it is of the order of 1,000 to 1 million times greater than the effect of molecular diffusion alone. It is very, very important, and must be considered in meteorological phases of any air-pollution investigation.

There are two types of this turbulence. One is the thermal turbulence when the air is unstable, and the air—you might say almost automatically—goes into a strong mixing process, churns and mixes the pollutant with the surrounding clear air very rapidly. This, in general, is a good situation for rapid diffusion of contaminants, except perhaps very close to a stack, where the gas might be carried down to the surface in relatively high concentration.

The other is the mechanical turbulence that we have when the air is not unstable—neutral, or maybe even in a very stable condition, such as the inversion condition that we have already heard of. This mechanical turbulence is just a stirring up of the air as it flows over obstacles at the surface of the earth, and may produce quite a bit of mixing. The mixing is very limited in the vertical under these inversion conditions, where the temperature increase is up in the atmosphere.

Another meteorological weather element that we have to be concerned with is precipitation, and it is important in two aspects. Example one is rainout. This is where the condensation nucleus in which the cloud droplet, which is the parent of the rain droplet, forms. When condensation occurs on this nucleus to form a cloud, and later precipitation, contaminants may be carried to the surface in that way. Or there is washout, which is the clearing of the atmosphere by the sweeping out of the contaminants as the rain drops, or perhaps snow falls, to the surface of the earth. These are two important areas where the atmosphere has an important role.

And then, of course, finally, the solar radiation. We are not going to dwell on this but it seems to be the source of many of the photochemical reactions which are so troublesome in this problem.

With regard to topography, this becomes important because of the fact that industrial cities, by and large, need to be near large supplies of water, and these are either found in a river valley or at a shoreline, say that of a large lake. Topography may be thought of as operating in two ways in relation to meteorology. First, topography may provide a physical barrier to horizontal diffusion. This is important, in Los Angeles, say, with the mountains around there. In any substantial river valley, the size of the valley just literally provides a physical barrier to the horizontal dispersion of the pollution; it is channeled in the valley. This channeling is very, very pronounced.

If you have any kind of a deep valley at all, the wind just blows up and down. That is, in the valley itself there are some crosswind components, but the air just doesn't flow as a unit up and over the sides of the valley. There may be, and often is, vertical diffusion by turbulence, which relieves the situation in the valley.

Then, the topography may complicate the diffusion pattern; for example, in one way, in what I would call an organized way, near a straight shoreline, where you may have land and sea breezes or land and lake breezes, these complicate the pattern of atmospheric diffusion and dispersion. Also, as I have just mentioned, in a straight, uniform valley, irrespective of what the flow is at the higher levels, the tendency for the flow is either up the valley or down. If the overall wind pattern and the free atmosphere above are light, the tendency is for the air to flow down the valley at night, up the valley during the day. And the third way in which you have organized complications, you might say, is near a uniform bluff or escarpment. But these are areas in which some analysis of the problem can profitably be made.

The really most difficult problem with topography is where it is very rough and rugged and irregular, and here, the problem is *very* difficult. If the terrain is sufficiently rough and irregular, it requires almost a meteorological analysis right at the spot to determine the air flow and diffusion.

Just a final thought on this first part then, on the importance of meteorology: the one point I would like to emphasize is that in this situation of high turbulence—high mixing, for example, downwind in the center line of a source of pollution—you may have a concentration of one part per million in a contaminant. Under low turbulence conditions—very poor diffusion in an inversion concentration—you may have, say, 1,000 parts per million, or even greater. There is a tremendous range here between the very high concentrations, and the very low concentrations which atmospheric diffusion provides. This is a very fundamental point. We can think then of the atmosphere as a major natural resource to be managed wisely.

I have listed a few points as outstanding problems or tasks. These are very sketchy and I am going to read them, very quickly.

(1) The existing meteorological knowledge is not being used adequately for the solution of community air-pollution problems.

(2) Communities should be shown how they can measure and use meteorological data inexpensively and conveniently.

(3) Air-pollution climatology should be developed on a national scale to provide a sound basis for a computed APPI, that is, an air pollution potential index, for every city in the country.

(4) Atmospheric contaminants, such as carbon dioxide, which may be causing long-period changes in our climate, should be monitored on a national basis at appropriate stations.

(5) Theoretical and experimental studies are urgently required—not only of diffusion at distances of 1 mile and beyond, but also, of the rate of natural cleansing of contaminant gases and particulates from the atmosphere by washout, rainout, gravitation settling, and turbulent impaction.

(6) Increased research on atmospheric pollution by air allergens, such as pollen spores and smuts, is required. This should emphasize: (1) meteorological influences on time quality and allergic quality of

the particulate emission; (2) the atmospheric transport of air allergens and possible modification of their allergy while airborne; and (3) meteorological influences on the allergic response of the receptors. Those of you who are afflicted with allergies, as I am, realize this can be quite important, and it is a significant public health problem.

(7) Theoretical studies are needed of the distribution of contaminants in, and for considerable distances downwind from, a large area source, such as a city. Such studies should be made in succession at four cities, chosen to be typical of the following meteorological and topographic conditions:

(a) a city situated on an open plain, without obvious meteorological peculiarities;
(b) a city in a typical river valley;
(c) a city on the shore of a large lake, such as one of the Great Lakes; and,
(d) a city subject to seasonally dense inversions.

A study of the first city involves "diffusion in a steady state" whereas studies in the second, third, and fourth require analysis of "diffusion in transitional states." The term "transitional states" may refer to transitions in the turbulence field, in time or space, or both.

The analyses of contaminant patterns in and around these four cities should then permit generalization of the results to cover the great majority of other cities.

Interreactions of Air Pollutants in the Atmosphere

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The previous speakers have discussed the kinds and quantities of pollutants in the atmosphere. You have also heard from Dr. Hewson about some of the meteorological aspects of air pollution. I would like to emphasize an important difference in two kinds of smog, which I shall exemplify by calling them Los Angeles smog and London smog. Table I has been prepared to summarize the differences between these two types.

The differences in meteorological and chemical characteristics of these two smogs are apparent in table I. London smog occurs on cold foggy days or nights. Los Angeles smog occurs in the middle of hot sunny days and appears to be primarily due to organic matter and nitrogen oxides reacting photochemically to produce ozone and eye irritation. One other point should be mentioned: several disasters have occurred with the London-type smog, not only in London, but also in Donora, Pa., and the Meuse Valley, in which from about a score to as many as 4,000 persons died. However, no such disaster has been recorded with photochemical smog.

In the remainder of this discussion, I shall devote my attention to the chemical reactions occurring in photochemical smog. Leighton and Perkins[1] have recently completed a very comprehensive report on this subject.

TABLE II. *Comparison of two types of smog*

Characteristics	Los Angeles	London
Temperature at time of occurrence.	75°–90° F	30°–40° F.
Relative humidity	$<70\%$	85% (+ fog).
Type of temperature inversion.	Subsidence	Radiation.
Wind speed	<5 m.p.h.	Calm.
Visibility at time of maximum occurrence.	$<\frac{1}{2}$ to 1 mile	<100 yards.
Months of most probable occurrence.	August–September	December–January.
Major fuel used	Petroleum products	Coal and petroleum products.
Principal components	Ozone, organic matter, nitrogen oxides, carbon monoxide.	Sulfur compounds, particulate matter, carbon monoxide.
Types of reactions	Photochemical plus thermal.	Thermal.
Effect on chemical reagents.	Oxidation	Reduction.
Time of maximum occurrence.	Midday	Early morning.
Principal effects on humans.	Temporary eye irritation	Bronchial irritation, coughing, sometimes increased deaths among those with respiratory diseases.

Primary Photochemical Reactions in Urban Air

Primary photochemical reactions which are judged by Leighton and Perkins to occur at significant rates in urban air are:

$$NO_2 + h\nu = NO + O \qquad \phi k_a(NO_2) \qquad (1)$$

$$RCHO + h\nu = R + H\dot{C}O \qquad (2)$$

The total rate of production of oxygen atoms will vary with solar radiation intensity and concentrations of nitrogen dioxide, and at times approaches 100 pphm per hour.

Reaction of Oxygen Atoms

Oxygen atoms will react with a number of substances known to be in urban atmospheres. However, consideration of about a score of possible reactions leads to the conclusion that over 99.5 percent of the oxygen atoms will react with molecular oxygen to form ozone, and less than 0.5 percent will react by all of the other processes added together.

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[1] Leighton, Philip A. and Perkins, William A., "Photochemical Secondary Reactions in Urban Air," Air Pollution Foundation Report No. 24. 212 pp., August, 1958.

Reactions of Ozone

The reaction of nitric oxide with ozone is very fast, and is complementary to the photolysis of nitrogen dioxide, followed by the reaction of oxygen atoms with molecular oxygen:

$$O+O_2+M=O_3+M \qquad (3)$$

$$NO+O_3=NO_2+O_2 \qquad k_1(NO)(O_3) \qquad (4)$$

Equating the rates of equation (1) and (4) gives

$$\frac{(NO)(O_3)}{(NO_2)}=\frac{\phi k_a}{k_1} \qquad (5)$$

All of the available evidence indicates that over most of the daylight hours in urban air the nitrogen dioxide photolysis and the nitric oxide-ozone reaction occur at higher rates than do any other known reactions involving the same substances. For this reason, the concentrations at which nitric oxide and ozone can coexist in air is severely limited. For example, if $(O_3)=20$ pphm, $(NO_2)=5$ pphm, and $k_a/k_1=1.0$, the rate of the nitric oxide-ozone reaction would equal the rate of the nitrogen dioxide photolysis at a nitric oxide concentration of only 0.25 pphm.

Various factors combine, however, to make the actual $\frac{(NO)(O_3)}{(NO_2)}$ ratio slightly smaller than the value calculated from equation (5). For example, consideration of the rate of the reaction

$$NO_2+O_3=NO_3+O_2 \qquad (6)$$

shows that it is from 300 to 1,000 fold slower than is the reaction of ozone with nitric oxide. Nevertheless, reaction (6) is still fast enough to be important in urban air.

Reactions of Ozone with Olefins

Several studies have been carried out to determine the kinetics of the ozone-olefin reactions and to identify the reaction products. The products include aldehydes, ketones, acids, carbon dioxide, water, and an aerosol. Intermediate products may include peracids, peroxides, hydroperoxides, and free radicals. Much more work needs to be done to understand these reactions, but the rates of reaction and concentrations are sufficient (1 to 10 or more pphm $hour^{-1}$) to be of importance in smog-forming periods.

Reactions of Ozone With Organic Compounds Other than Olefins

Reactions of ozone with saturated aliphatic hydrocarbons, acetylene, and aromatics, at concentrations occurring in air, are apparently too slow to be of any importance.

Ozone-ketone and ozone-aldehyde reactions have received little attention. Estimates of the rates of reaction suggest that these reactions may be of importance. Kinetic studies must be made before any conclusions can be drawn on the extent to which these compounds are involved.

Reactions of the Oxides and Oxy-Acids of Nitrogen

The authors considered about a score of these reactions and calculated rates using the following exemplary concentrations

$(NO) = 0.25$ pphm $\quad (O) = 10^{-6}$ pphm
$(NO_2) = 5$ pphm $\quad (H_2O) = 2 \times 10^6$ pphm
$(O_3) = 20$ pphm $\quad (NO_3) = 3 \times 10^{-3}$ to 1.3×10^{-3} pphm

Judging from these exemplary rates, the reactions which are fast enough to be important during smog-forming periods in urban air are:

$$NO + O_3 = NO_2 + O_2 \tag{4}$$
$$NO_2 + O_3 = NO_3 + O_2 \tag{6}$$
$$NO + NO_3 = 2NO_2 \tag{7}$$
$$NO_2 + NO_3 = N_2O_5 \tag{8}$$
$$N_2O_5 = NO_2 + NO_3 \tag{9}$$
$$N_2O_5 + H_2O = 2HNO_3 \tag{10}$$

Free Radical Reactions

In the great majority of photochemical reactions which have been studied in detail, it has been found that the primary process consists of a dissociation of the absorbing molecule into free radicals or atoms. Consideration of the concentrations and types of organic molecules in the air leads to the conclusion that free radicals exist in the smoggy atmosphere. Leighton and Perkins' conclusions are summarized in table II.

TABLE II. *Primary photochemical free radical formation*

Radical formed		Absorber possibly forming the radical	Minimum absorber concentrations necessary to form the radical at a rate of 1 pphm hour^{-1} in air at $Z=45°$.
Name	Formula		
			pphm
Alkyl	$\dot{R}$	Aldehydes	8
		Ketones	40
		Alkyl nitrites?	0.2
		Peroxyacyl or acyl nitrites?	3
Formyl	$H\dot{C}O$	Aldehydes	8
Acyl	$R\dot{C}O$	Ketones	40
		Diketones	10
		Acyl nitrites?	3
Alkoxyl	$R\dot{O}$	Org. peroxides	100
		Alkyl nitrites?	0.2
Hydroxyl	$\dot{O}H$	Hydrogen peroxide	7
		Nitrous acid?	(1)
		Nitric acid?	100

[1] Not known, but rate is probably <0.1 pphm hour^{-1}.

The last column in table II gives the minimum concentration of each absorber which would be necessary for the photochemical formation of the radical concerned at a rate of 1 pphm hour^{-1} when the solar zenith angle is 45°. Comparing these figures with what is known about the actual concentrations of the absorbers leads to the following conclusions, applicable to representative smog-forming periods in urban air:

1. Alkyl radicals are probably formed at a rate in excess of 1 pphm per hour as the result of the aldehyde photolysis, together possibly with the alkyl nitrite and peroxyacyl or acyl nitrite photolyses.
2. Formyl radicals are probably formed at a rate in excess of 1 pphm per hour, also through the aldehyde photolysis.
3. Alkoxyl radicals may possibly be formed at a rate in excess of 1 pphm per hour by the photolysis of alkyl nitrites.
4. Acyl and hydroxyl radicals are probably not photochemically formed at rates of as much as 1 pphm per hour.

In addition to these primary photochemical processes, one secondary reaction, that of ozone with olefins, may be a significant source of free radicals in urban air.

The available evidence indicates that the alkyl, formyl, and acyl radicals, as well as the hydrogen atoms, formed in air will react almost exclusively with oxygen to form the corresponding peroxyl radicals. Any hydroxyl radicals formed will probably react chiefly with the natural hydrogen in the atmosphere to produce water and hydrogen atoms, which will in turn react with oxygen. Thus, four peroxyl radicals, peroxyalkyl, peroxyformyl, peroxyacyl, and hydroperoxyl, probably result from these reactions.

As a consequence of their rapid reactions with oxygen, the stationary concentrations of alkyl, formyl, and acyl radicals, as well as that of hydrogen atoms, will all be quite low in urban air, while the concentrations of some of the peroxyl radicals and of alkoxyl radicals may be surprisingly high.

The situation regarding the secondary reactions of peroxyl radicals is much less clear. For each type of peroxyl radical there are a number of possible reactions among which, on the basis of present information, it is impossible to decide.

With alkoxyl, formate, and acylate radicals a similar situation exists, in that present information is not sufficient to permit an assessment of the relative importance of several possible reactions.

Summary

Reactions judged to occur at significant rates in urban air are:
Primary Photochemical Processes:

$$NO_2 + h\nu = NO + O \qquad (1)$$

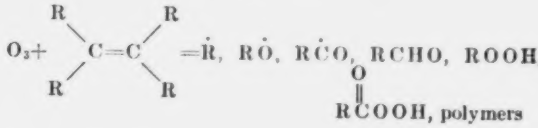
$$RCHO + h\nu = \dot{R} + H\dot{C}O \qquad (11)$$

Secondary Reactions:

$$O + O_2 + M = O_3 + M \qquad (3)$$

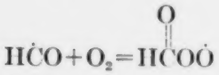
$$O_3 + NO = O_2 + NO_2 \qquad (12)$$

$$O_3 + NO_2 = O_2 + NO_3 \qquad (13)$$



$$O_3 + R_2C{=}CR_2 = \dot{R},\ R\dot{O},\ R\dot{C}O,\ RCHO,\ ROOH,\ R\overset{\overset{O}{\|}}{C}OOH,\ \text{polymers} \qquad (14)$$

$$NO + NO_3 = 2NO_2 \tag{7}$$
$$NO_2 + NO_3 = N_2O_5 \tag{8}$$
$$\dot{R} + O_2 = RO\dot{O} \tag{15}$$



$$H\dot{C}O + O_2 = H\overset{\overset{\displaystyle O}{\|}}{C}O\dot{O} \tag{16}$$

In addition, there are about two-score reactions which may or may not occur at significant rates, but for which there are insufficient data to make a decision.

It is noteworthy that the only hydrocarbons appearing in the reactions are the olefins. No paraffin hydrocarbon reaction appears because none was found to occur at a sufficient rate. Barring unknown reactions, it may be concluded that the paraffin hydrocarbons are not significantly involved in the process of smog formation.

The Influence of Air Pollution on the Electrical Properties of Air

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San Francisco, Calif.

Normal atmosphere contains electricity in the form of air ions. A small air ion is a positive or negative charge associated with a cluster of gaseous molecules. In addition to small ions, ordinarily clean atmosphere contains a few charges attached to solid or liquid particles, and these are commonly termed intermediate and large ions. These particles are primarily submicroscopic, with diameters ranging from 3 to 100 millimicrons. There are many other submicroscopic particles without electric charge, and the charged particles appear to be reasonably representative of all particles present.

In clear air at sea level there are on the average 500 to 600 small ions of each polarity per cc; at higher elevations, 14,000 feet, for example, the density may reach 2,000 to 2,500 per cc. In urban centers, for example, San Francisco, air pollution has reduced the average small-ion density to less than 100 per cc of each polarity, about one-sixth the normal density; the number of larger ions (that is, the charges on particulate matter just mentioned) has increased.

Continuous measurement for 8 years in San Francisco has revealed that the small ion density remains relatively low and relatively constant throughout the year. This is in marked contrast with clean country air, where fluctuations are the usual pattern and the density averages several times greater.

During periods of visible air pollution many large ions are found to be present. At other times, even though there is no visible pollution, many large ions are found to be present. At other times, even though there is no visible pollution, invisible pollution is shown by the presence of a substantial number of intermediate ions. It is interesting that there is a direct correlation with traffic density, and hence with the amount of automobile exhaust from traffic congestion. The living habits of San Franciscans have been clearly recorded on ion density charts. The typical work day, traffic to the major football and baseball games, and even Saturday night out-on-the-town, leave a distinctive pattern easily identified.

Small ions in their biological importance were not understood until recently. However, scientists at the University of California have made quantitative measurements of physiological changes in the trachea (windpipe) caused by exposure to positive and negative small ions. As a result of these and other studies it has been established that small ion content of the atmosphere is an important component of our physical environment.

In normal air, because of the high mobility of small negative ions, a current of approximately 4×10^{-16} amperes per cm^2 is received on the membranes of the trachea. This ion current has been observed to stimulate the normal function of the windpipe in removing contaminants from air entering the respiratory system. Lack of these ions in contaminated air prevents an increase in this physiological activity when it is needed the most.

On the other hand, a positive ion current of 12×10^{-14} amps per cm^2 has a tendency to depress the normal windpipe mucus flow and cilia activitv. Also, when the carbon dioxide content is higher than normal, a high density of small positive ions increases this effect. Fortunately, a high density of small positive ions does not usually occur with air pollution, although it may result as a byproduct of air conditioning.

There can be no doubt that pollution of the urban atmosphere has markedly altered its electrical characteristics. This fact makes possible physical measurement for observing the degree of air pollution, particularly invisible or submicroscopic contamination. Perhaps of greater importance, the increasing evidence of the biological significance of air ions adds to the cumulating knowledge that air pollution is a serious hazard to our health.

DISCUSSION

Dr. Harrison E. Cramer. It was stated this morning that in the case of air-pollution incidents you had not been able to isolate the irritant in any way—in Los Angeles, for example, or in London. It seems that you really are not in a position to know what it is you want to measure. So certainly one objective, as you pointed out, was to develop improved and, I presume, rather expensive methods of isolating the irritants. On the other hand you call for inexpensive, simple techniques. These must be nonselective, I presume. So isn't it necessary for you to know more about the irritants you want to isolate before you can specify a measurement program?

Dr. Haagen-Smit. It was clearly stated that the ones we don't know we can't apply any specific measurement to. But there are certain ones that you can, and one of them, for example, is hydrogen sulfide. The measurement of carbon is pretty good, and some of the nerve gases. We are not fumigated that way in Los Angeles, although it looks sometimes that way, but there are relatively inexpensive ways of doing this work. In summarizing this we should not make a kind of homogeneous mixture of all pollutants. That is probably where the misunderstanding is. I think that what you actually want to stress is that we do fundamental work on the identification of the unknown components.

Mr. STERN. I think one of the things you are alluding to is that along with any work on increasing our knowledge of the identity and quantity of pollutants, we have to do work along parallel lines on determining the effect of pollutants on humans, on animals, on vegetables, and so forth, in order to increase our knowledge of what it is we want to identify and measure.

I feel sure that the reports of several of the other discussion groups are going to include the conclusion that we don't know enough about the effects of air pollution on human health, on vegetables, on animals, and so forth, and that we will have to have further information to find out what specific pollutants are causing these adverse effects. This, however, is another group's prerogative to call attention to and not ours.

Dr. LODGE. Just one further amplification of this point. You probably know our group at Taft Center is doing the bulk of the work that is carried on in the Public Health Service which falls directly into the categories Dr. Cramer has alluded to. I would say very definitely that there are two separate and distinct categories there. One is the search with extremely complex tools for new and previously unidentified chemical species. Quite distinct from this is the development of new analytical methods and new instruments for the measurement of those substances which have already been shown either to have physiological effects or for other reasons to be worth watching. We do have inexpensive methods out in the field so that we can amass enough data really to converge on the overall problem. But these are very distinct research problems.

Mr. GRUBER. One of the techniques by which we can very simply and without a great deal of technical skill evaluate the results of air pollution as it pertains to soil or disfigurement is by noting the degree of stain on white filter paper. This is one of the big things we are concerned about, and I think that that particular process merits a great deal of thought in the development of any continuing monitoring program.

R. C. WANTA. So far in the discussion an item has been left out which may confound some of our intensive efforts in monitoring which are proceeding today and are expected to continue. This is the question of what in the set of "dosage-concentration-time" for some particular pollutant is most significant. It seems to me that we should have in a discussion on monitoring programs some reference to known mechanisms of biological impact to permit us to consider the question whether records such as we take in monitoring networks—which essentially are averages over long periods of time, like a month or a day—can serve for the class of effects which may result from concentrations of pollutants rising above a particular threshold. It is not clear to me that one can recover necessarily from data of this sort that the concentration for a day was X parts per million. This is the average. It is not clear to me that from data of this sort you can recover information which might also pertain to the same day—i.e., the number of times that the concentration of pollutant A exceeded a certain threshold level during the day.

This then suggests that there is a need to pay considerable attention to the question of the variety of mechanisms for, let us say, biological insult, so that our generalized monitoring schemes at least in some part will be able to answer questions raised.

Dr. Haagen-Smit. Is this a recommendation that we use more continuous monitoring instruments? Would you then be able to distill the information you want? Or do I understand you incorrectly?

Mr. Wanta. It is a question of practical economics of the type that Dr. Lodge referred to this morning. It also serves to underline Dr. Cramer's comments. It is a bad military principle to attack simultaneously along the whole front. You are sometimes perhaps forced to do this. It is, as Dr. Lodge stated, a syllogism leading to an astronomical figure if we continuously monitor for all pollutants everywhere. We can't do this. Somewhere along the way we must focus our effort. We all appreciate this. I don't have a solution to offer, but we must recognize that the problem exists of how to focus our effort with respect to particular insult mechanisms, where the significant item is concentration over a certain threshold occurring for a certain period of time.

Dr. Cholak. This is the multiple prediction factor which I mentioned this morning, by which, taking London for example, you might take the average concentration of sulfur dioxide, dust particles, weight of particulate matter, or any other contaminant such as carbon monoxide; or you might take data that occur in excess of a certain level occurring normally; and relate these data to atmospheric conditions such as temperature, humidity, and duration of the incidence, say, of inversion.

Dr. Lodge. Mr. Wanta has raised a very good point and it should be underlined. Let's say that I were to die at the age of 50, and my daily mean intake of arsenic during that period was in the order of a tenth of a microgram. I think you would all agree that the tenth of a microgram spread over all day would not necessarily produce fatal effects, provided that this was distributed—provided it was not concentrated. We do not have from the medical people any real guide lines as to how far it is valid to assume that the product of concentration and time is proportional to response. I think it is pretty obvious that if you kill the organism, it stops responding and the equation breaks down.

Continuous reading is not necessarily an answer here. For example, many of our so-called continuous recorders, continuously record a running average. The classic nitrogen dioxide recorder is an excellent example of this. It has a very long averaging time. The experimental ozone monitor that is on display here is the completely opposite case. It was actually necessary to put a little something into the circuit electronically just to avoid painting the chart. In between these extremes there is some reasonable time resolution which is necessary to give completely valid results, if a point is reached at which concentration × time is not proportional to response. I think Mr. Wanta is quite right. We don't know enough to agree what this point is, and this is not something we can go out and immediately fly into on a nationwide basis. We don't know enough to do it. We don't know enough not to do it. What we need to do is to study along with other things this question of how much resolution we must have.

Dr. Haagen-Smit. The plant toxicologist is in much better shape. There we have the tree rings that show, let us say, from 2,000 and

3,000 years ago what kind of damage might have been done by a forest fire or perhaps a chemical attack, but as far as we know this isn't exactly applicable to man.

Dr. JACOBS. Mr. Wanta brings up the very important point that the biological insult at any given time for any given concentration may be the effective factor in causing illness or harm and that this will be lost in a general average. This is one serious objection that I have had to the National Air Sampling Network, which takes a 24-hour average of total suspended particulate matter on successive days every second week. So you start Monday, and 2 weeks later you do it on Tuesday, etc., and then you get very nice averages or totals, as shown on the slide this morning by Mr. Stern. Such a system of analysis does miss the highs on any one given day. If you were to have a very high value of total suspended particulate matter for, say, an hour or two, and then have relatively low values, your high would disappear in your average. And of course, if you had an incident for 3 days in any given month and your 2 weeks spanned it, you would miss it entirely, and you might not pick this up for another 10 years. This of course would not show in your averages.

Does this then mean that we have to monitor for every single day every single hour in order to get our peak results? Not necessarily. We know, and I speak of New York City monitoring, that our maximum amount of pollution for nearly every day in the year occurs from about somewhere in the time between 6:00 and 10:00 a.m., and if we take a sample at, say, 9:00 to 9:30, or 9:30 to 10:00, depending on whether the chemist comes in early or not, then we are able to get by and large a peak result for that day. This might not work so well in statistics, but it is of greater value for the determination of biological insult.

So then you have to use discretion. You have to choose something which will be indicative of the general pollution. In New York City, we have lots of sulfur dioxide, so we have adopted this as a system for monitoring. Now you have, of course, to be cautious where you use an automometer to get an integrated average. We use an electrical conductivity measurement, and then get a response with 20- to 30-second lag, giving us a peak for every minute of 24 hours. Then, since I never trust a machine anyway, I always run a wet test method during the day to check on our monster. So in between these methods you can make a judicial selection so that you can get those peak biological insults that may occur on a daily basis.

Mr. STERN. I think that all of the discussion has indicated that the question we are trying to answer—where do we stand at the moment in our knowledge of the identity and the quantity of pollutants in community atmospheres?—perhaps was not the proper question that should have been asked us, in that it lacks the important time factor. Somewhere, in both the question and the manner in which we answer it, we have to inject the time factor, which had been left out up to this point. We will take that into consideration in redrafting this material for submission.

Dr. JOHNSTONE. What have you accomplished with the data that you, the control officials, the people from industry, have accumulated?

There have been recorded air pollution episodes where people have been hurt and have died. There are a great many of these incidences.

Let's look into what causes these incidences in Europe and in the United States.

It has been pretty well demonstrated that a very serious condition for health, mentioned here many times, is the accumulation of sulfuric acid particles in the air, especially along with sulfur dioxide. More recently work in Harvard University has shown that very low concentrations of sulfur dioxide cause very serious biological effects in a very short time, especially when present with certain nuclei that we know are present in cities in this country. I charge you, the United States Public Health Service, and those city officials who have in your hands the lives of people, to watch out for this condition.

Let me read you some data taken from a report by Grohs and Saline, under the title of "Atmospheric Pollution, the Role Played by Combustion Processes."* Outer London sites during the 1952 smog when 4,000 people died within a few days: average concentration of sulfur dioxide, .35 part per million, maximum .56. Outer London sites of the same type in 1948, .19 average and .31 maximum. In December 1951, .12 average. Pittsburgh, 1931–32, .30 average, 2.5 maximum. Donora during the smog disaster in 1948, a report by the United States Public Health Service: an estimate of a maximum of 2 parts per million.

Ask yourself, do you have higher concentrations in your community? If you do, watch out for the other things that may be present that will convert that sulfur dioxide into toxic sulfuric acid droplets in a few minutes. We have done it within 2 minutes after the formation of the fog in the laboratory. We have analyzed the amount of sulfuric acid.

What are these particles? Manganese sulphate, which is present around steel mills and various other sources. We know that these particles are also present in the combustion products of certain fuels.

Here are more data: In the commercial area in Chicago in 1937, .41 parts sulfur dioxide per million, maximum of 3.16.

William S. Foster. The perplexing things that face many of us in this may be clear to a lot of you gentlemen that are in more closely allied scientific fields than I am. What is dirty air? When does it become clean and acceptable air? What can you have in it?

You can't remove everything. The fact that you have sulfur dioxide in the air, and certain other things under certain conditions, doesn't make it easy to draw up an ordinance that will guide a city official in protecting his people. And the cities do have that responsibility to protect themselves.

I have heard automobile and truck gases denounced rather broadly, and yet we have no standard to say that we should restrict the gases at such and such a point in order to encourage the manufacturers to produce an engine that will meet these requirements. The automobile manufacturers are not going to correct this with no more than suggestions from people like ourselves. I can see how they would be encouraged to do so if the cities or States were to pass licensing ordinances saying that a car of such-and-such character would have to pay a much higher license fee.

This I miss in this discussion. I would be grateful for enlightenment firming up where we who are interested in city government can start from, so that if we wish to prepare a good ordinance we can. I don't know whether it is enough to try to scare people and tell them if we keep breathing this we are going to get cancer. It was also brought out that there is a connection between cigarettes and cancer, and yet I see within our own group here people bravely smoking cigarettes. I see the sale of cigarettes rising despite this.

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I don't believe that we can invoke the kind of constructive steps we need by frightening people without giving them a base to start from that all of us can understand. I would like to make a plea, since you are speaking of tests, for a simpler method of making tests. Tests for the average city with the personnel it has are very difficult. If there were some way that those tests could be simplified, it would be a great help.

Dr. McKee. Your question has pointed the finger at several areas where about the best we can say is that we do need more information. I personally have had the experience of conducting a fairly extensive air-pollution survey, and it is a relatively easy matter to go out in the field with a monitoring instrument or a mobile laboratory or whatever type of equipment you use and measure different substances and tell people in the community, "In this area we usually measure less than such-and-such parts per million of SO_2," and so on. It is much more difficult to answer their next question, which is invariably, "What does this mean to me? Is this good or bad?"

You can compare it with other cities, but this is only a partial answer. The whole question of what constitutes an acceptable or an unacceptable state of cleanliness of the atmosphere is a very difficult one to answer. One partial answer is that the atmosphere can be as clean as the people wish it to be and are willing to pay for making it. Again this is only a partial answer.

Some of the impossible situations are perhaps illustrated by trying to relate sampling data with subjective reactions, such as odor, eye irritation, and so on. There is information in the literature which indicates that sulfur dioxide can be detected by odor by most persons if the concentration is greater than perhaps $1\frac{1}{4}$ or $1\frac{1}{2}$ parts per million. At the same time I have had the experience of being out in the field and smelling SO_2 and right away I trap a sample and run a test and measure maybe one- or two-tenths of a part per million. There are some possible explanations for this, but this just illustrates the complexity that you run into.

Dr. Chambers in Los Angeles has made a statement to the effect that 15 percent of the people in Los Angeles have never experienced eye irritation, and yet eye irritation for a large majority of the population is the source of their complaints. This is not an answer to your question. It is just a couple of illustrations of the general state of confusion which now exists and which points up the need for more work both in the chemical and medical aspects and more particularly in the interrelationship between the two.

Dr. Haagen-Smit. I would agree that we do need more toxicological work to determine some kind of a level, and if we don't have that, then we are more or less probing in the dark, and to get that certainly would be very expensive.

Mr. Couchman would like to add something to the array of chemicals that we have to test for. They are a little bit more complicated than the ones we have been talking about, but I think they do belong in this chapter.

Mr. Couchman. It was observed this morning in many of the papers that more emphasis was placed on what I will term the chemical environment. I have reference to the industries, the contaminants, the odors—in other words, man-made pollution. Only brief references were made to those pollutants of harmful nature which come from natural causes. From a public health viewpoint, the nuisance value, the discomfort, the suffering, as well as the morbidity rates, are much more significant than those conditions brought about by the chemical environment. I have in mind such things as the allergens, the pollens in nature. Also, I wish to mention some of the work that has already been done in air hygiene, of biological processes which use air as a medium, whereby individuals contract communicable diseases. I know it is probably beyond the scope of many of us here who are technically trained in engineering or chemistry to consider these foes, but I don't believe that it is beyond the horizon of the objective, to determine the extent of air pollution.

Dr. Johnstone. A lot of data accumulated by a lot of different people over a number of years will not establish a trend that has much value. Our job is to analyze the air in communities to see if there are times when dangerous situations may exist. I don't like quite to use the word "dangerous" because this infers that all the objections to air pollution are in health. There are other things, such as damage to property and well-being, that are also important. There may be objectionable odors, too.

Dr. Lodge. There has been some criticism of the National Air Sampling Network from the viewpoint that it does not show high values. However, it does give an integrated picture of the air pollution of the country. It gives the kind of answers that it was designed to give. These are the trends and the statistical distribution of 24-hour mean values.

I agree completely with Dr. Jacobs that this says absolutely nothing about insults or 1-minute means. It was not designed to. I think nothing would make Mr. Stern and me happier than to have enough money to run 1-minute averages in all these cities. If such information is needed and is wanted badly enough to pay the price, we will be very happy to pitch in and help get this information. The trends in these 24-hour means can be determined, will be determined from present data. I don't believe we know enough yet to do the kind of extrapolation that can be done in such matters as rainfall, of going from 24-hour means to a prediction on what insult peak levels will be. This is something else that needs to be looked into, but I do feel that this sort of information on long-period means is of value, and what we need is not to throw the baby out with the bath water but to purify the bath water a little. We need additional information to give this still more meaning.

Dr. Scott. It might be interesting, since we have been involved in laboratory work and also in sampling in the field, to let you know something about our philosophy at Franklin Institute. I think that there is general agreement that the times we need to fear are when the pollution is at a peak for any length of time. From the health point of view, then, we are not really interested in average situations. We are not interested in average weather. We are not interested in average pollution. Our research and our objective have been to find out what goes on by studying it in the laboratory and in the atmosphere.

To do this and to find out what might be present in the atmosphere in order to give the toxicologists and the public health people ammunition so that they can go to work, we have to know something about the range of pollutants that might be found under adverse conditions, under conditions where you would expect the concentrations to be the highest, and this gives us some idea of the range of pollutants that might be issuing to the atmosphere. It gives us the data we need to go into the laboratory and study a range of concentrations in more detail than we could do in an outdoor laboratory.

Now we have been in three locations in the Los Angeles basin with our infrared sampling equipment. Most of this time we have just been conducting research in our trailer. It has nothing to do with atmospheric sampling at all. We are interested in periods in the Los Angeles basin when they have confinement of the pollution. We are interested in measurements during "alerts" when, as measured by the ozone level, the general level of pollution is high.

Now you must remember that we are not dealing with a homogeneous kettle out there. We may have an "alert" that is called as a result of measurements of ozone at a control district station that is located right where our trailer is. On the other hand, the "alert" may be called 15 miles away. This basin is not a very homogeneous thing. You can have high concentrations in one part of it and no eye irritation or any adverse effects that anybody notices in some other part of the basin, so that our philosophy has been to try to determine extremes. Under these conditions we can establish ranges where we can carry out further laboratory work and try not only to establish what can accumulate in the way of primary pollution during these periods of confinement but also to do some work on products produced photochemically, the type of thing that Dr. Rogers was talking about this morning.

I think some meteorologists have called attention to this. One of them, I think Scorer, who is the editor of the *New International Journal on Air Pollution*, has a recent book called *Natural Aerodynamics*, in which he tries to outline some basic principles and goes on to talk about problems. There is a lot of information in this book pertinent to a study of air pollution and he makes a very strong point of this, that we are not interested in average conditions. From a social point of view we should be interested in extreme conditions, and I think that there are many cases where we have data that indicate that either there were more people sick or more people died, and so on, and these times were always associated with extremes in pollution.

Dr. GLENN R. HILST. I would like to make a comment closely allied with Dr. Scott's and add an elementary caution on the basis of statistics of sampling. It is well known to the meteorologists that if you wish to increase the rainfall over an area, all you have to do is to install more rain gauges. This simply reflects the fact that you do work with a heterogeneous distribution, and as you increase the knowledge, as you increase the number of sampling points, you perhaps increase the probability of measuring the true maximum. This is a factor well worth mentioning. Trends might emphasize the fact of increase in sampling rather than the true trends.

Dr. Jacobs. I would not want anyone to think that any monitoring program should not be reappraised from time to time, but it is a function and a very important function of any regulatory agency to be in a position to warn the public and to take steps in the event of any dangerous situation arising. This is no new principle. For instance, nearly every large city has a department of health which monitors its water on a daily basis and monitors its food on a daily basis, particularly the milk supply, and I am sure that no one would advocate that, say, a department of water supply should abolish its laboratory because they didn't find any typhoid bacteria for, say, some 20 years. You must keep a perpetual watch to find out whether any danger will exist. It is unlikely that conditions will improve and improve so much in the next few years that you can get away with not maintaining air monitoring programs simply for the purpose of warning in the case that dangerous conditions do exist.

G. C. Gaeke. On the National Air Sampling Network and on Dr. Scott's ideas of measuring extremes . . . we need both very much. We need the data on extreme days so that we have sufficient concentrations of these pollutants to find out what is happening on these days. But we need all the data from the National Air Sampling Network so that we can establish base lines from which to measure pollution in Community A when it begins to get to be a problem. If we have a base line of data, then we can find out if this community is above similar communities in similar areas or whether it is strictly a local affair in this community. But I think we need both data.

James Halitsky. Still on the subject of the National Air Sampling Network, I would like to request some clarification as to what its purpose is, what information it intends to show, what and how is it intended to be used, and what use is intended to be made of the information that it produces. Now the statement was made that the network is doing the duty to which it was assigned. I haven't yet heard what is the purpose of this network.

Now if the network is merely acting in retrospect, that is, after a year's time to find out what happened last year, I would like to find out if there is any instantaneous network in existence which registers an alarm when the pollution situation at any given time approaches what we currently feel is the limit which would be tolerable.

Mr. Stern. First we would very much appreciate knowing what those limits are at which the alarm should be rung. One of the main purposes of the large-scale collection of data is to get enough information so that we can have data which can be correlated against morbidity and mortality statistics in various communities to see if any relationship between pollution concentration and constituents and mortality and morbidity exists, and to see if there is any trend in any of the data that will lead us to run up the red flag and become concerned about an approach to these limits that you discuss.

One incidental value of the National Air Sampling Network has been that it provides at very low cost a method for individual communities to look at their own air-pollution problem. In addition to having certain technical and scientific merit in the amassment of data, it has the additional value of being a very good means of selling air pollution control to the public.

David Standley. The National Network has been measuring total weight of particulate material. There have been several investigators who have demonstrated that the adverse health effect of certain contaminants is a function to some degree of the total number of particles of given size ranges that are present. Nobody is doing any work along this line to any extent that I know of. There are no available good data that would permit you to take the National Network results and arrive at numbers of 400 micron particles or half micron particles which would serve as adsorption media, act as contaminants, or act as catalysts, or what-have-you. I would like to see some concentrated work done along this direction. Perhaps we have the tools to do it now to a certain degree, the Cascade Impacter and the Particle Counter, and I think this should be an aim of the National Network as soon as possible to get some data of this nature.

Dr. Lodge. However nice it would be to have this information, I doubt if one could defend the cost of obtaining it on a nationwide scale under present costs. We have every intention—and the Public Health Service has not laid out at this conference a detailed statement of its plans of research for the next few years—to make pilot studies of this sort. However, the cost of making this sort of determination at some two or three hundred stations would be completely astronomical. I think you are aware through our exhibits that there is a plan to make 24-hour mean measurements of concentrations of certain gases in the atmospheres of all the Network cities, and this will be implemented.

No one will say that this can conceivably catch all the acute episodes. It is not what the network itself was set up to do. There is a system in existence so that when we think we sense a serious situation developing the operators of the network are told to look out and, if it is getting sticky outside, start their sampler even if this isn't the regular sampling day. But we simply are not set up and the network was not designed to get acute levels. The network cannot absorb the cost of doing a complete particle size spectrum on all these samples either.

Dr. McKee. I might just give a few figures which illustrate the difference in cost involved in a weight determination such as the National Air Sampling Network is now doing and a particle size determination. First, for the weight determination, a high volume sampler costs $134 unless they have changed their price recently. The only instrument I know of which would be completely suitable for a particle size distribution on an automatic basis is something similar to the Chemical Corps aerosoloscope, which has never been mass-produced but is hand-produced and costs something in excess of $100,000. The only other technique for particle size determination that one might adapt is something like the Cascade Impacter you mentioned. These are relatively cheap, but the collection of suitable samples for counting is somewhat of a problem, and the sizes of particles which are of most interest from a physiological standpoint are those which are submicroscopic, below the limits at which accurate particle size determination can be made with an optical microscope. So this gets into electron microscope techniques, which are very tedious and for which the number of man hours required very quickly approaches the astronomical. I think this is the reason why they decided on the techniques they are now using and why we have decided on the same techniques for slightly different purposes but in somewhat similar circumstances.

Roy Vallance. I was formerly with the State Department. I wonder to what extent standards have been established as to what is safe chemical pollution. You are familiar with the studies made at Detroit on the boundary air pollution there between Detroit and Windsor, and of course you are familiar with the Trail Smelter case, which caused Canada to pay to the United States for damages for the pollution in the State of Washington from the Trail Smelter. To what extent is there exchange of information internationally, and to what extent is there a standard set up? Do you recall the tests that were made? The decision reached in Detroit, as I recall it, was that there was not sufficient pollution there to cause any action to be taken.

Dr. Cholak. I think that standards have been set for certain specific pollutants, and sulfur dioxide is one of those where it has been shown that at a level of half a part per million under certain atmosphere conditions and certain periods of time, damage does occur. So that if the level is below a half part per million, usually damage does not occur. The same thing is true for hydrogen fluoride in the atmosphere, although there the problem is a little more confusing. It is not any more difficult, since fluoride is one of the more toxic pollutants insofar as vegetation is concerned. Damage has occurred in some very sensitive plants at levels as low as one part per billion. That is a very low concentration. Also there are some other levels that can be set for fluoride, for instance, regarding air-pollution problems resulting from the concentrations of fluoride in the vegetation that is used for forage. Usually in this case a level below 35 parts per million in the vegetation is considered safe for farm animals where the damage is not compensable. This is the way I think the levels are set. And there are others for lead and arsenic than can be set, but on the basis of long years of study with these in fieldwork.

Mr. Beckett. I thought I should comment on the question of particle size determination, particularly in view of the comments that have been made regarding costs and the problem of measuring submicroscopic particles. By taking the mobility spectrum of submicroscopic particles in an electric field, you can very closely approximate the size of the particles with electrical equipment; and the cost of such equipment, such as we are using in San Francisco, is about $6,500; it covers the full range from 3 to 100 millimicrons.

Dr. McKee. Will $6,500 just equip one station or let you look at samples from a multitude of stations?

Mr. Beckett. One station.

Dr. Francois N. Frenkiel. I believe it was mentioned by Mr. Stern that one of the main purposes of the national sampling system is a scientific one and the secondary purpose is that it brings to the attention of the communities what is going on. In this connection I would like to remind you of the statement by Dr. Burney yesterday, who said that the main problem of this conference is to bring the problem of pollution to the attention of the people and the community. I therefore, and for this reason only, believe that the air sampling system does contribute to solving the atmospheric pollution problem.

but I do not believe that it has any scientific value whatsoever, and I do believe also that we are overemphasizing this question of scientific problem. There are many scientific problems, extremely complicated, this is true, but it is possible to do quite a lot without understanding everything.

The difficulty is to convince people that something should be done. The question of how bad is it before it is pollution also has an answer. In Los Angeles we know from the concentrations during certain days that they are above the concentration which is acceptable by industrial health.

Victor H. Sussman. In line with what has been said, I think we have ignored one of the readily usable constant recording instruments that is an accurate method of determination of air pollution and also a prime mover in control, and that is the human sensory organ. The panels for odor control are well known, but I believe that the very fact that air pollution does manifest itself as an attack on the sensory organs is the primary mover for control and that chemical measurement is a secondary aspect of it. Dr. Haagen-Smit and many of his colleagues in Los Angeles have proved this by correlating their investigations with eye irritation episodes and manifestations such as this.

One other point as to particle size measurement: Has any consideration been given to the particle spectrometer developed by Caltech?

Mr. Stern. That instrument is commercially available; it costs $2,500.

Dr. Amos Turk. With regard to remarks about measurement of odor just made, I think we should remember that emphasis on odor is really a measure of perceptual impact and not a measure of material content of anything in the atmosphere. However, I presume that the sampling network will be available as its function expands to collection of vapors and gases which would give us additional information on contaminants and possibility for perceptual impact.

Mr. Gruber. In the comments there was no reference made to the matter of measuring the index of soiling. In a number of communities, and particularly our own, we have had this soiling index for at least 5 years at three different stations, and that is on a day-in-and-day-out basis. It does give you to a certain degree these peaks that we were talking about. They may be in our case 6-hour peaks; in a great many cases they are down to 3-hour peaks. I do think that should be considered when we are talking about trends actually in the monitoring program.

(Unidentified). The pollution meteorologist's position is a unique one. He stands as a middleman in the problem and the solutions of his particular problems are very much dependent upon his knowing what the problems are both at the source and at the receptor. For example, the source strength, its configuration, and its position with respect to the receptor and with respect to irregular terrain, set the initial and boundary conditions which he must consider. Then he has the whole complex problem of dispersion in a turbulent atmosphere to consider, and finally, so that their results may be useful, he must know what the period of average concentrations of interest is and the levels or the tolerance levels for various receptors and for various pollutants. Therefore he really has to work with the whole problem or he can not satisfactorily fulfill his role.

Looking at it in reverse, it makes him a very valuable man, for in getting at his problem, the dispersion of materials in the atmosphere, he must eliminate insofar as possible such extraneous variables as those which arise from source strength, and he must tackle head-on the statistical problem of proper sampling, so as to resolve the concentrations in terms of the proper kind of average and in terms of the temporal variations and in terms of spatial variations.

A properly qualified pollution meteorologist stands as an excellent sampling man in the air pollution problem for he must do his work in terms of the problem if he is to be useful.

Mr. **Standley**. After you get your equipment and collect your data, the biggest single problem is handling the data, and I think it would be a great service and an economical measure if some central agency, perhaps Public Health Service, could arrange, assuming that enough people get equipment to make this a worthwhile service, to pick up these rolls of charts and what-have-you, put them into form usable by the local agencies, simply as an economy move to use a central calculating agency, if you will. This might be done on a cost basis.

Mr. **Gruber**. We have heard from time to time the possibility of seeking a single index of meteorological conditions as they affect air pollution, that is, dropping in various meteorological parameters into a single index. I didn't gather that that is one of the objectives to be sought. I am wondering if, as of the moment, that seems to be out of the question. As an administrator it would be the thing I would ask for, that I could come up with every day a single index rather than worry about eight or ten things. I would like to see where we stand on that.

Maynard Smith. Dr. McKee mentioned earlier the very excellent solution of some of the simpler problems in meteorology, such as the Trail problem, and that type of thing. I know what Mr. Gruber means in terms of seeking a simple index, or at most two or three. We have merely begun, I think, on the communitywide scale as far as these entire investigations are concerned. Let's look back at the progress that has been made in some of the simpler instances. At Brookhaven, for example, we had a meteorological and diffusion problem to solve and now we feel that we can depict quite accurately the mean concentration, the peak concentrations, and the entire variability from a single wind instrument. While I don't think that a community solution will ever be quite that simple, I would look forward to the circumstances where, knowing the time of day, a few relatively simple measurements would give you an excellent idea of the pollution levels to be expected.

Dr. **Hewson**. The problem is extremely complex and is not generally amenable to a single index, but if you can accept rather wide tolerance limits, that is, in its predictive value of average concentrations, then it is possible to simplify things considerably. I refer to predictive value in the sense that knowing the parameter variations, you know the extremes.

A related point is this—air-pollution climatology should be developed on a national scale to provide a sound basis for a computed APPI—this is air pollution potential index—for every city in the country. This is important, this concept of pollution potential, because it would give us some idea of how nearly we are approaching what you might call saturation conditions. Now obviously Los Angeles is in many cases already in or in some cases beyond saturation conditions.

This idea of the potential of the atmosphere in the vicinity of various cities is important. I know Dr. Landsberg and his group in the Office of Climatology in the Weather Bureau have done some preliminary work, and I think there has been some other preliminary work carried out, but I don't think any of these have been followed through to the point where we could actually provide the kind of information that is needed. In other words, how near are we to saturation in our various communities?

Dr. H. E. LANDSBERG. You get on dangerous ground when you talk about potential pollution index. I would like to comment on a rather neglected element—the rainfall, the wash-out. We only talk about the things that tend to accumulate pollution and rarely talk about things that eliminate pollution, and I feel in any meteorological program that ought to be a prime parameter. Because if you did have even a dangerous pollution for a very short time, if that were followed immediately by an adequate rainfall which would wash out pollutants, it wouldn't concern you very much. The duration factor is, according to my point of view, the most important and the most difficult one to assess. We can probably make a fairly good prediction as to stability, wind, and what the pollution will be from insult sources, even multiple sources, but how long it will last, how it will accumulate in time—that is a difficult one—and how will it be eliminated—those two questions I feel ought to be emphasized in the future studies of this problem.

Dr. CHOLAK. I would like to ask Dr. Landsberg if rain occurrence is a factor in inversions.

Dr. LANDSBERG. It could be. I can conceive a certain type of wind conditions when you have either rain or snowfall impending, and you have under this particular system a very heavy pollution which later is eliminated.

Dr. MCKEE. In this discussion of a pollution index, I detect two separate ideas which perhaps we should clarify. There is perhaps a need for an overall pollution index which will describe the average pollution potential, for an entire year's time perhaps, for a community, so that this index can then be compared with another community and say that City A has an index of so-and-so and City C has an index of so-and-so. Apart from that, there is perhaps also a need for another index which would give a day-by-day measure for a single community. So that when Mr. Gruber gets a phone call from an irate Cincinnatian who complains about air pollution, he can say, "Yes, we know it is bad today but the index is 5 whereas yesterday it was only 3.5." Is there need for both of these different kinds of indexes, city by city, and also day by day, within a given city?

Dr. CHOLAK. I wonder what this index is going to take as a criterion. Some response will have to be worked out in order to arrive at an index. I wonder what the members of this audience think would be suitable criteria or responses, physiological responses if you are thinking about health aspects. And those are the difficult ones to determine. I think your index will have to be related to some response.

Dr. Hewson. What we can provide is not the limits, the physiological limits, that are required but we can give some idea of the probable accumulation; we still come back to the physiological response. Certainly it would help to be able to say that for such-and-such a city an index of 5 is dangerous and requires drastic action. We meteorologists or climatologists are still dependent on the physiologists for the answer to that, but I think we should be proceeding in a parallel pattern to study this from the meteorological and climatological points of view so that if these criteria became available we can then immediately adapt them for these practical purposes.

Mr. Wanta. An air-pollution potential index, which Dr. Landsberg introduced, is perhaps all right if not taken too literally. There are a number of examples which might be given for this, but before I illustrate the defects, let me show how it might work. In a given community even an arbitrary potential index which had some merit would tend with practice to find an interpretation of scale values. In other words, it is not clear to me that we have to go in knowing what the response relationship is. The difficulty here, though, is more essential than that. The weather effects on air pollution refuse to be classified. They resist simple classification. A single air-pollution index is not to be expected as a useful thing for all air-pollution problems in a community. There are inherent contradictions, for example, in these two situations. One, a protracted, a lengthy period of very light wind movement in which the effluent from a city remains in the neighborhood, is siphoned off to some extent but tends to accumulate—a phenomenon with a time scale of several days. Illustrations are London and Donora. Then contradictory is the following situation: a portion of a community within, let's say, a fraction of a mile from a large source of heated effluent. In the case I have just mentioned of protracted light winds, these are the conditions for which the buoyancy of the gases operates quite well. You will see the accumulation. The process by which that effluent does get to influence the community at the surface is a lengthy one involving a layer of gases staying in the neighborhood. Then convection processes would bring portions of this from the layer aloft back down to the surface. But the buoyancy of hot gases is easily overcome in the atmosphere. It takes a strong wind and, although wind is generally appreciated as a primary factor in the sense that the slower the wind the less the movement, if you are within a mile of such a source, the days which are likely to produce the highest peaks of concentration of that heated effluent are the days when the wind is strong and the buoyancy is licked fast, so that down-wash may occur. It is in that situation that the close-in receptor suffers. It isn't clear to me, therefore, that one pollution index could cover adequately both of these situations.

Dr. Landsberg. Dr. Haagen-Smit, we need some more additional people in this field also, the training aspects. Some new research people should be educated in these lines, because I believe strongly we do not have enough now to conduct all necessary research.

Perhaps a hint could be taken from the U.S.S.R. They have recently attempted to get the cooperation of universities and have assigned certain air-pollution research problems to what they call "aspirants" for their theses. If we can do something like that here, we would both spread the gospel and develop a broader interest among younger people.

Dr. **Benjamin S. Levine**. You are right in principle and this is actually being done. There is a very wide project at the University of California in Los Angeles, and I am quite sure that you will now find in many different universities work towards the doctor's degree in air-pollution fields. As you know, there are about 14 courses in different universities giving curricula which tend to educate people to the job of taking care of future pollution. We can not afford to leave that just to a chemical engineer or a civil engineer. There are too many disciplines that we have to learn about.

Mr. **Halitsky**. As was well put yesterday, we do not need to know exactly the relationship between contaminant and a particular biological effect to set into operation measures to prevent harm to people. Whatever the merits of the National Air Sampling Network, it does not appear that an adequate warning system is available in most communities to forewarn of an approaching critical condition.

Since the recommendations of this conference will bear on the allocation of funds of the Public Health Service, I earnestly suggest that attention be devoted to the development of instantaneous detectors for wide distribution. The exact thresholds will have to wait for laboratory correlations, but it is not too soon to alert the public as to the general level of instantaneous concentrations in the air as well as suspected harmful levels.

Dr. **M. M. Gilkeson**. In many cases the problem of air pollution has become at least regional in scope. The jurisdictions involved are many, cutting across county and State lines and affecting manufacturing units, commerce, Government, and the individual as well.

The cost of data collection is so high that it behooves us to make maximum utilization of the data that are obtained. However, data are often confidential and difficult to compare on a standard basis when they are released. Further, the agencies collecting the data often owe their existence to groups which are emotionally involved in the nature of the reported results. This is not meant to imply that such agencies are intentionally nonobjective but simply that in many cases the more logical instrument for carrying out research is the nonpolitical and nonprofit research organization—the university or research foundation. The university is a particularly appropriate agency in that its research in this field assures to Government and industry a supply of scientific and engineering personnel with backgrounds and interests which will enable them to fulfill its manpower needs for pollution control.

Emphasis by both Government and private industry, including their research organizations, in the support of university research into aspects of pollution, is a worthwhile objective.

While governmental support may be largely monetary, of equal need is the release by industry of appropriate data (still on a confidential basis). The value of problem solutions in this field is so great that it is not to the self-interest of any party to retain secret data of use in overall correlation. For the solution of our most weighty problems the trilogy of Government, industry, and nonprofit research organizations in a working partnership is a requisite.

DISCUSSION GROUP "B"
SOURCES OF AIR POLLUTION

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Theme

"Where Does it Come From?"

Questions for Discussion

1. Where do we stand in our knowledge of the specific and relative contribution to community air pollution from

- (a) nature?
- (b) individual industrial and commercial activities, and categories of these?
- (c) public agency activities?
- (d) activities by individuals?
- (e) activities outside the community affecting the incoming air supply?

2. What, if anything, should be done further on these matters, and by whom?

Domestic and Municipal Sources of Air Pollution

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The major contributions to air pollution from domestic sources are the products of combustion from space heating and refuse incineration. Municipal sources are identified with construction activities, with the operation of sewers and sewage treatment plants, and with the collection and disposal of refuse.

Categorizing these sources by types and quantities of pollutants is fraught with danger because the actual quantities of pollutants cannot be measured accurately. Averages must be resorted to, but these will vary with the seasons, and with the fuels used, as well as with the methods of sewage treatment and refuse disposal employed.

The tables below have been prepared to show estimated atmospheric contaminants from each source. They have been compiled from various data and represent an attempt on the part of the author to synthesize values from widely divergent material and to seek a balance which could be applied to *average* situations in many parts of the country where filed data are not available.

It is recognized that there is no substitute for accurate field measurements. But many a time it is not possible to make these and some basis for estimating should be available. Compilation of the data for these tables has been on the basis of the convenient parameter of 100,000 persons. Interpolation can be applied for a metropolitan area of any population, or for any fraction of the population which uses coal, oil, or gas for space heating, and any of the methods of refuse handling and disposal. These tables therefore represent an attempt to establish a base line for *average* contributions to the atmosphere from domestic and municipal activities.

Importance of These Sources

1. *Domestic Sources*

From table 1 it is evident that space heating can contribute large or small quantities of pollutants, depending on whether coal, oil, or gas is used. Gas as a fuel for water and space heating can be dismissed from consideration because it will give no significant contamination to the air. Oil heating contributes large quantities of oxides of nitrogen and sulfur, as well as organic substances. It has been shown in Los Angeles that organic acids, hydrocarbons, and aldehydes are present in the local smog and that some of these tend to reduce visibility and may constitute a public health nuisance.

TABLE I.—*Pounds of contaminants discharged daily from domestic sources in a metropolitan area of 100,000 persons*

Principal contaminants	Pounds per day per 100,000 persons using each category of heating and refuse disposal					
	Fuel—Domestic Heating			Domestic incineration		
	Coal	Oil	Gas	Backyard burning	Household incinerator	Apartment incinerator
SO_x	42, 000	17, 000	0. 4	180	1	12
NO_x	8, 000	6, 000	6	90	1, 150	30
H_2S	1, 000	500	0. 1	---	-----	24
NH_3	2, 000	800	0. 3	345	-----	24
HCl	2, 000	500	0. 3	---	-----	--
Aldehydes	2, 000	800	1	600	8, 400	72
Organics	20, 000	4, 000	1	42, 000	12, 000	1, 800
Organic acids	30, 000	12, 000	1	225	1, 900	4, 800
Solids	200, 000	800	0. 1	3, 400	16, 500	4, 000
Total of above categories	307, 000	42, 400	10	46, 800	40, 000	10, 700

NOTES:
SO_x—oxides of sulfur—SO_2 and SO_3.
NO_x—oxides of nitrogen.
Aldehydes measured as formaldehyde.
Organic acids measured as acetic acid.
Total includes only above categories and does not imply total contamination in the ambient atmosphere.

Coal-burning home and apartment-house heating furnaces can lead to a large contribution to the air pollution of an industrial city. The first column of table I shows what might be expected if the entire population of a metropolitan area of 100,000 used an average grade of bituminous coal. Solids, oxides of nitrogen and sulfur, and various organic substances are all high. These have all been implicated in the increase in severity of air pollution. In Louisville, with only 35 percent of the homes heated by coal, and 60 percent by gas, it was shown that coal-burning home furnaces accounted for 83 percent of all pollutant gases, 84 percent of organic material, and 99 percent of all solids emitted by home heating equipment.

Domestic incineration is widely practiced. Thousands of communities do not have adequate refuse collection facilities and force the citizens to resort to backyard burning of paper, leaves, and assorted debris. It was not until October 1957 that 1,500,000 backyard burning devices were banned in Los Angeles County. As shown in table I, this is a major source of air pollutants, mostly organic matter and solids. Individual household incinerators have not fared much better than backyard incineration in the past, as shown in table I. Their use has been discouraged in Los Angeles, Detroit, Pittsburgh, and

Philadelphia as they could contribute a significant amount of smoke, odors, and solids to the atmosphere if their use were widespread.

In New York City alone, there are approximately 10,000 apartment-house incinerators serving 1,500,000 people. It has been estimated that by 1970 there will be 13,000 of these incinerators, which will service about 23 percent of the population, or 2,000,000 people. These incinerators are desirable from the standpoint of reducing the volume of refuse to be collected by the city and as a convenience to tenants and property managers. The significance of fly ash particles, smoke, and odors comprising the pollution emitted from these incinerators can be attested to by the records of complaints received by the Department of Air Pollution Control. These records show that approximately 25 percent of the total complaints received concern incinerators and that in the summer, when windows are open, the percentage climbs to the range of 70 to 80.

2. *Municipal Sources*

Refuse disposal is the major source of air pollution from municipal activities. Estimated quantities of airborne contaminants from an area of 100,000 people using each method of disposal are shown in table II. Open burning dumps are still in vogue in many municipalities despite the obvious contamination of the air with smoke, solids, and odors from the many organics. Visibility is greatly reduced in the area near the dump and the other undesirable effects on the populace are well known. It should be emphasized that the "hooded monsters" patterned after sawdust burners and used extensively in New Jersey for uncontrolled, but partially enclosed burning, are not far removed in principle nor practice from open burning. The fly ash, smoke, and odors are merely concentrated in a plume 20 to 30 feet above the ground.

TABLE II. *Pounds of contaminants discharged daily from municipal sources in a metropolitan area of 100,000 persons using various refuse disposal methods*

Principal contaminants	Pounds per day per 100,000 persons using each category of refuse disposal		
	Incineration	Burning dumps	Sanitary land-fill
SO_2	290	180	
NO_x	320	90	
H_2S	---	---	Trace.
NH_3	45	345	Trace.
Aldehydes	168	600	------
Organics	210	42, 000	Trace.
Organic acids	90	225	------
Solids	3, 450	7, 000	Variable.*
Total of above categories	4, 570	50, 400	Low.

*Depends on amount of ashes being placed and amount of dust in cover material. Can be controlled.

In order to abate air pollution from refuse burning, controlled high-temperature combustion must be utilized in modern refractory-lined incinerators. Table II shows the expected discharge of contaminants from a municipality of 100,000 having a modern incinerator with adequate air cleaning and good operation. These values can be and are exceeded in many areas in which overloaded, poorly designed and operated units contribute fly ash, smoke, and odors to the community. But this need not be the case. The values presented in table II should have no significant effect on air pollution.

The use of sanitary land-fills has been advocated for Los Angeles, the San Francisco Bay area, and others where every effort must be made to reduce all sources of air contamination. Sanitary land-fill can be the most economical method of refuse disposal if cheap land is available nearby and if the process is well operated and the refuse covered daily with virtually dust-free earth. Table II indicates only a trace of contaminants because the rate of decomposition of the covered refuse is so low that the resulting methane, ammonia, hydrogen sulfide, and carbon dioxide cannot be detected in the atmosphere above the land-fill.

Relative Significance in Overall Pollution

Assessment of the significance of domestic and municipal sources has been attempted in table III. The average daily emission of air contaminants was computed from the average values of the estimated emissions from the metropolitan areas of New York, Cincinnati, Louisville, Chicago, Portland, San Francisco, and Los Angeles. These were presented on page B-19 of the "Literature Review of Metropolitan Air Pollutant Concentrations" submitted on November 30, 1956, by the Stanford Research Institute to the Army Biological Warfare Laboratories under SRI Project No. SU-1816. Values were averaged and reduced to a composite metropolitan area—residential and mixed industrial—in which 100,000 persons reside and work.

TABLE III.—*Comparison of air pollution contributions from domestic and municipal sources with total air pollution potential of metropolitan areas*

Contaminant	Pounds per day per 100,000 persons			Percent of total contaminants	
	Total metropolitan activities	Domestic and municipal sources			
		Case I	Case II	Case I	Case II
SO_2	62, 840	20, 347	2, 635	32	4
NO_x	34, 240	4, 480	1, 462	13	4
H_2S	4, 040	5, 050	105	12	2
NH_3	2, 782	1, 241	201	45	7
Aldehydes	3, 620	1, 456	309	40	9
Organics	129, 400	42, 760	1, 329	33	10
Organic acids	28, 720	15, 540	3, 433	54	12
Solid particulates	337, 200	85, 120	3, 720	25	11
Total of above categories	603, 000	172, 000	13, 200	[1] 32	[1] 7

[1] Average of percentages of each category.

To obtain quantities of air pollutants through the realistic use of tables I and II, two metropolitan areas were assumed, with different domestic and municipal sources of air contaminants. The total number of persons using each type of space heating fuel and each type of refuse disposal are itemized below for each case:

CASE I.—*High contamination*

Fuel	*Persons*	*Refuse*	*Persons*
Gas	20,000	Apartment incinerators	20,000
Coal	40,000	Backyard burning	40,000
Oil	40,000	Burning dumps	40,000

CASE II.—*Low contamination*

Fuel	*Persons*	*Refuse*	*Persons*
Gas	60,000	Apartment incinerators	20,000
Oil	40,000	Municipal incinerator	80,000

The total number of pounds of contaminant from each case was taken in proportion to population from tables I and II.

It will be noted that under the assumed conditions case I will contribute 32 percent of the total oxides of sulfur, over 40 percent of the total organic matter, including aldehydes and organic acids, and 25 percent of the particulate matter or solids to the atmosphere of the hypothetical metropolitan area, which includes a mixture of heavy and light industries. These contributions appear to average over 30 percent of the various categories and would be highly significant in the overall pollution problem. On the other hand, in case I the highest relative value is 12 percent of the total organic acids in the atmosphere of the metropolitan area and only an average of 7 percent of the various contaminants. Thus the municipal and domestic sources are not significant in this case. Therefore, each metropolitan area must be studied separately, perhaps with the aid of the data in tables I and II and the method demonstrated in table III.

A comparison of the Louisville findings of 1957 might be in order. These represent the atmosphere above the West End of Louisville, an area of heavy industry and residences. Fuel consumption for domestic space heating was 60 percent gas, 5 percent oil and 35 percent bituminous coal. The findings are noted in table IV:

TABLE IV.—*Percentage contribution of gaseous and solid contaminants from all sources in the West End of Louisville*[1]

Sources	*Percentage*		
	Gaseous	*Solids*	*Total*
Domestic	6	3	9
Transportation	6	0.1	6
Industry	78	7	85
Total	90	10	100

[1] From: "The Air Over Louisville"—Summary of a Joint Report, Louisville & Jefferson County, Ky., 1958.

This condition approaches case II and the results are also of the same order of magnitude, which indicates that with such a large percentage of domestic users of gas the domestic contribution to air pollution is hardly significant.

Variations in the Future

Improvements are taking place in home incinerators through the activities of the American Gas Association and manufacturers of equipment. Double chamber units, with auxiliary fuel supplied to each chamber and adequate controls, should assure a higher quality effluent. Further acceptance of domestic garbage disposal by kitchen grinders may also follow as the sludge handling facilities of sewage treatment plants are increased. Apartment-house incinerators are also being improved, particularly through the efforts of the New York City Department of Air Pollution Control and New York University. Much improvement in air quality can be looked for in double chamber incinerators with auxiliary fuel, and rigid legislation and enforcement of their use.

As far as space heating is concerned, the greatest contribution to air-pollution control would be the continued shifting from hand-fired coal furnaces to gas and oil. The outstanding accomplishments in Pittsburgh and St. Louis are a matter of record. The public is still looking for oil burners which will cut down the organics shown in table I, not to control air pollution as much as to get more heat out of every gallon of fuel oil.

In the municipal field, refuse incinerators can be improved upon. More rigid design standards must be adopted and enforced by regulatory agencies to achieve the best design for each refuse problem. Designing engineers and manufacturers have just begun to stress air cleaning because of the cost factor of $100 to $2,000 per ton of installed daily refuse burning capacity. And when a city of 100,000 requires an incinerator with a minimum capacity of 240 tons per 24-hour day, the cost of air cleaning can be high. These factors will lead to more municipal incinerators, each capable of burning more refuse, but discharging less solids and organics than at present.

Burning dumps will be legislated against in most States before many years, if the contemporary action of the people in many heavily populated States is any criterion. Composting is widely used in European and Asian countries but it has not been proven economically feasible in the United States, principally because there is no large market for the finished product. Sanitary land-fills provide an excellent means of refuse disposal for air-pollution control, but the land requirements are so high—about 10 acres per year for a city of 100,000 people—that many cities have run out of available land within a reasonable hauling distance. Incineration remains the only economical solution for the refuse disposal problem of many cities and the writer expects a great increase in the number of units in the next decade. More rigid air cleaning procedures, as well as more rational design criteria to provide better combustion, must be adopted in many cities to prevent an increase of pollutants from this source.

Sewers and sewage treatment plants can be controlled to be reasonably free of odor nuisances. It may be necessary to treat certain industrial wastes before discharge to municipal sewers, or to chlorinate or practice other odor control means in the sewers. Adequate design criteria will control sewage treatment plant odors. Increased activities of water-pollution control agencies and more effective design criteria will lead to an expansion of treatment plant construction all over the country and will cut this source of air pollution to a minimum.

Improvement Programs

Space heating research has been carried out for years by equipment manufacturers and research groups such as the John B. Pierce Foundation of New Haven, Conn. More efficient fuel utilization in oil furnaces is a "must," not only from the standpoint of cutting down the discharge of organics to the atmosphere, but also for oil companies and burner manufacturers to continue to compete with gas-fired units. This developmental work, as well as research on coal stokers for homes, should be carried out by industry.

On the other hand, new design criteria for apartment house and municipal refuse incinerators should be developed by research agencies, such as universities and governmental laboratories. The U.S. Bureau of Mines and the Public Health Service have made significant fundamental contributions to the art of refuse combustion. These studies have enabled better incinerators to be built by refractory contractors, with a minimum amount of equipment to be sold by manufacturers of stokers. The development of simple and efficient air-cleaning devices for incinerators should also be undertaken by the same research laboratories because much remains to be done in establishing design criteria for devices which can be installed within or adjacent to the breeching or flues of existing incinerators.

Domestic incinerators leave much to be desired from the standpoints of simplicity and economy of operation. The housewives are in favor of such equipment and a large potential market awaits the development of completely acceptable units—acceptable by air pollution control authorities, as well as housewives. Therefore, the equipment manufacturers, together with the purveyors of gas or electricity, should undertake even more extensive studies than they have in the past. This could be a rapid development, as the principles of double chamber combustion using auxiliary fuel to assure organic odor destruction are well established.

Summary

Significant contributions to the pollution of the ambient atmosphere of a metropolitan area are made from domestic and municipal activities, particularly space heating and refuse disposal. The relative importance of these sources in the overall picture increases with the use of coal for heating and open burning of refuse and decreases markedly as more homes and apartments use gas and oil for heating and destroy or dispose of refuse by controlled methods. Two hypothetical cases have been presented—one in which domestic and municipal sources were responsible for 32 and 7 percent of the area's total air pollution.

It is evident that more refuse will be burned in incinerators—household, apartment, and municipal—as the years pass. Cities are running out of land for sanitary land-fill disposal of refuse, and composting has not been economically successful. Research and development work by manufacturers of equipment and by university and Government research laboratories should lead to more effective combustion, less smoke, fly ash and odors from the furnace, and better and more economical air-cleaning methods. The total contribution of pollutants from this source may well remain constant over the years as more refuse is incinerated and less discharges per ton occur.

Space heating can also be improved through research activities of fuel suppliers and furnace and stoker manufacturers. One of the principal variables is the relative price of fuel. As natural gas becomes more available an increase in its use may well lead to a substantial reduction in air pollution from domestic sources in the years ahead.

DISCUSSION

Alfred Fletcher. Because ragweed pollen is one particular pollen which causes so much sickness every year beginning at a certain time, and because ragweed pollen is produced in tons per acre per season, and because ragweed pollen can be controlled, it would seem that this is something important enough to be included among the lists of contaminants from municipalities.

It comes from some other areas but we usually produce the ragweed pollen in cities because of our activity and failure to do properly certain things. Without the activity on the part of people in cities, we wouldn't have the ragweed pollen. It is easy to control and I believe it should be included.

C. George Segeler. Would Dr. Eliassen indicate what type of domestic incinerator he had in mind when he secured the data?

Professor Eliassen. I got the data from a number of sources and it was not on the latest model of double chamber unit. It was one of the older units. I understand there are two, the apartment house incinerators, the larger ones, and the domestic incinerators, which are much improved from the double chamber, with higher ignition temperatures.

Hitchcock ran one long ago in California and some data came from more modern work. It was, again, an attempt to have an average situation, hoping that the American Gas Association and others who I understand are working on it, will improve that picture.

Mr. Segeler. That has been accomplished.

Mr. Bloomfield. Would you comment on the flash-drying process of sewage as a municipal source?

Professor Eliassen. It's not too prevalent in use but if you ever go on the southeast-northwest runway at Chicago Municipal Airport with the northwest wind blowing, you are heading right into the stacks of the sludge dryers of the sewage treatment plant. That is a gross pollutant of the atmosphere in the Chicago area.

I do not thing it's typical of the modern designs there because all they have are cyclones, which they are forcing at quite a high rate, I understand, but I have taken pictures of the brownish-red stuff coming out of there, as seen from airplanes. As with gas incinerators for households, there have been many improvements made, using multiclones if necessary and using spray chambers to cut down the dust.

It is a source of odors if not properly operated. Those odors and the fly ash and dust can be controlled with the application of modern engineering principles which cost money, so I would say there is hope. It's a pretty good method, a very good method, if you can operate it properly. One of the difficulties there is that they dry the sludge and then cool the gases with incoming ones and sometimes they volatalize organics, which can give you some very nice odors. I think it can be controlled.

Professor Chanlett. Dr. Eliassen, do your figures on table 3, Solid Particulates, include dust of traffic origin, street dust, and if so, is there any information on how much that amounts to and whether it makes any difference whether you do or don't have good municipal housekeeping in terms of cleaning from your streets solid particulates and airborne dust?

Professor ELIASSEN. I don't know. I think it's included in the figures because you are picking it up. What percentage it is in the role of municipal housekeeping I don't know. I haven't seen the data on that but it certainly could be significant and I think is one source of a municipal nature that must be evaluated.

Industrial Sources of Air Pollution (1)—Petroleum Refineries

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(Read by Gerald Fisher)

The potential contribution of an industrial activity to community air pollution is determined by the quantity and the character of the contaminants it emits.

Thus, petroleum refineries must be viewed as major potential sources of air contamination. The pollutants derived from their operation represent a broad spectrum, including dusts, fumes, smoke, and the smog-reacting hydrocarbons.

On the average, a petroleum refinery not equipped with any special air-pollution control equipment may emit as much as 2½ tons of significant contaminants into the air for each 1,000 barrels of crude oil it processes.

Since nearly 8 million barrels of crude oil are refined daily in the United States, air-pollution emissions from this single source category would total approximately 20,000 tons per day. These emissions would include oxides of sulfur, particulate matter, hydrocarbons, oxides of nitrogen, ammonia, aldehydes, and organic acids. Substantial additional qualities of carbon monoxide also are released.

Since a modern petroleum refinery is an extremely complex system of processing units, the control of potential air-pollution sources is both difficult and expensive. Pollution leakage can occur from hundreds, if not thousands, of sources in a refinery. Every pump gland

and pipe fitting must be viewed as a possible, if only a small, source of air contamination.

Experience in Los Angeles County has shown that pollution emissions from petroleum refineries can be cut by more than 80 percent, but at a cost for air-pollution control equipment ranging from 5 to 10 percent of the total plant investment. For a new refinery costing $100 million, more than $5 million would be required for nonproductive air-pollution control equipment.

From the production of crude oil to the delivery and use of the finished petroleum products, air pollution considerations are becoming of increased importance to the industry itself, and to the communities it serves.

Operations of the petroleum industry may be conveniently divided into three major categories: (1) production of crude oil; (2) refining of the crude oil into finished products; and (3) distribution and marketing of the products.

In the United States, present crude oil production amounts to nearly 7 million barrels per day while crude oil runs to stills, a measure of refining activities, amount to about 7,600,000 barrels per day.

Oil Production

In oilfield production operations, emissions to the atmosphere consist chiefly of light hydrocarbon vapors, principally methane, with smaller amounts of ethane, propane, butane, and heavier hydrocarbons. Some of the emissions occur as a result of evaporation from the crude oil storage tanks and other oilfield equipment. Hydrocarbon emissions associated with the production of crude oil in Los Angeles County have been estimated at about 50 tons daily. Other types of air pollution from oil fields are minor. There are typical odors associated with the operations, but they do not appear to cause any problems.

Petroleum Marketing

The marketing of petroleum products involves transferring the products by pipeline, tank trucks, or railroad tank cars. Since most of the products are volatile hydrocarbon liquids, these transfers can be accompanied by emissions to the atmosphere of hydrocarbon vapors displaced from storage tanks. In Los Angeles County, control measures to minimize these losses have been adopted. The controls involve vapor recovery systems or floating roofs for storage tanks and vapor recovery facilities for truck loading racks. Hydrocarbon emissions from marketing operations in Los Angeles County now amount to approximately 55 tons per day. This includes emissions from small uncontrolled loading racks, delivery to service station underground tanks, and the filling of automobile tanks. The remainder of this report is concerned with the air-pollution problems of oil refineries.

Oil Refineries

The refining of crude petroleum into marketable products requires the application of complex physical and chemical processes involving heat and pressure. To accomplish this a refinery uses a great variety of equipment, including storage tanks, furnaces, boilers, distillation columns, reactors, pumps, pipelines, and valves, all handling more or less volatile hydrocarbon materials within extremes of temperatures and pressures.

These refinery operations are a potential source of air contaminants, such as smoke, dusts, sulfur compounds, hydrocarbon vapors, and malodors. It will be shown, however, that it is quite practicable to control the emissions of these contaminants from refinery operations, or reduce them to a point where they cease to be a matter of concern.

Los Angeles is only one of several major refining centers in the United States which are subject to air pollution from this source. However, the topography and meteorology of the Los Angeles basin, plus its high population density and lack of public transportation system, are responsible for the unusual air-pollution problems of the area. Unlike the usual air-pollution problems that plague other industrial centers, Los Angeles smog is chiefly associated with eye irritation accompanied by reduction in visibility. Consequently, the most intensive efforts to study the problems of air pollution from refineries and to control the emissions from these sources have taken place in Los Angeles.

Studies of oil refinery operations and emissions of air contaminants from these sources have been in progress by the Los Angeles County Air Pollution Control District since 1949. These studies have made possible the adoption of control legislation by the Air Pollution Control District specifically covering such emissions and have resulted in the installation of control equipment by the industry. During the past several years the Air Pollution Control Committee of the Western Oil and Gas Association has also conducted an intensive study of sources of air pollution from refinery operations. This study was responsible for the installation of equipment to control many sources of pollution before control measures were passed.

Joint Project Studies

During the past 3 years a study of the emissions of air pollution from refineries in the Los Angeles area has been made as a joint effort of the Air Pollution Control District, County of Los Angeles; Bureau of Air Sanitation, Department of Public Health, State of California; Public Health Service, U.S. Department of Health, Education, and Welfare, Community Air Pollution Program; and the Western Oil and Gas Association, Air Pollution Control Committee. This study is called the Joint District, Federal, and State Project for the Evaluation of Refinery Emissions.

The results of the Joint Project Study have been published in nine reports, which are available at a small cost from the Los Angeles County Air Pollution Control District. The reports are titled:

Report No. 1.—Interim Progress Report, July 1, 1956
Report No. 2.—Hydrocarbon Losses from Valves and Flanges, March 1, 1957
Report No. 3.—Hydrocarbon Leakage from Pressure Relief Valves, May 1957
Report No. 4.—Atmospheric Emissions from Catalytic Cracking Unit Regenerator Stacks, June 1957

Report No. 5.—Emissions of Hydrocarbons to the Atmosphere from Cooling Towers, August 1957

Report No. 6.—Emissions of Hydrocarbons to the Atmosphere from Seals on Pumps and Compressors, April 1958

Report No. 7.—Emissions to the Atmosphere from Boilers and Process Heaters, June 1958

Report No. 8.—Emissions to the Atmosphere from Eight Miscellaneous Sources in Oil Refineries, June 1958

Report No. 9.—Final Report, 1958

Results of Joint Project Study

There are 6 major and 12 independent oil refineries in Los Angeles County, with a total crude oil charging capacity of over 700,000 barrels daily.

The overall objective of the Joint Project was to determine the nature and quantity of air contaminants being emitted as a consequence of these refinery operations. To accomplish this it was necessary to conduct field surveys, develop or adapt sampling and analytical methods, carry out a field testing program, and evaluate the results.

The total average daily emissions from the oil refineries in Los Angeles County were shown to be as follows:

	With controls
Hydrocarbons	103 tons
Oxides of nitrogen	56
Sulfur dioxide	145
Particulate matter	10
Sulfur trioxide	5
Ammonia	5
Aldehydes	5
Organic acids	5
Total	334

Assuming that none of the potential pollution sources were curbed, contaminant emissions would total as follows:

Hydrocarbons	800 tons
Oxides of nitrogen	56
Sulfur dioxide	745
Particulate matter	100
Sulfur trioxide	25
Ammonia	5
Aldehydes	5
Organic acids	5
Total	1, 741

Sources of Emissions and Controls

Losses of volatile hydrocarbons occur from the storage of large volumes of crude oil and distillate products. Crude oil storage capacity in the area totals about 7 million barrels. Emissions to the atmosphere from this source amount to 15 tons per day. These are all low-boiling, saturated hydrocarbons and as such are regarded as having a low smog-forming potential. The Air Pollution Control District Rule 56 covers the storage of distillates having a vapor pressure in excess of 1.5 pounds per square inch but does not apply to crude oil. Such distillate must be stored in tanks equipped with floating roofs or vapor recovery systems. These two methods of storage represent the accepted and most practical approach to this problem. Due to the large storage capacity of over 20 million barrels for such products and to the rather rapid turnover of stocks, daily emissions from this source average 27 tons per day.

Catalytic cracking regenerator stacks emit 20 tons daily of hydrocarbons, largely methane. Methane does not appear to be a contributor to air pollution, since it is inert, colorless, odorless, nonirritating, and nontoxic. Other contaminants from this source include carbon monoxide, oxides of sulfur, oxides of nitrogen, ammonia, and catalyst dust. Combinations of some of these with water vapor present give rise at times to visible condensation plumes. The carbon monoxide is emitted in large quantities, totaling 1,200 tons daily.

On large units and where additional processing steam is needed, it is practical to control carbon monoxide emissions by installation of a waste heat boiler. This essentially eliminates the carbon monoxide but does not affect oxides of sulfur and probably increases the oxides of nitrogen. One such installation is in use in this area and two more are in process of construction. Although carbon monoxide is a poisonous gas there is no evidence that it enters into any of the smog-forming reactions. Ground-level concentrations in the area are of little significance since they are far below safe limits.

Catalyst dust is controlled in all of the cat-cracker installations, complying with a regulation which limits the allowable discharge to 40 pounds per hour for each process.

Another important source of hydrocarbon emissions which is controlled by regulation is the oil-water separator. Large quantities of water are used in refinery operations. The water becomes contaminated with oil which must be removed before the water is discharged. API separators are normally used to separate the oil by gravity. Light oil fractions may evaporate from the surface of these separators. In Los Angeles these separators are required to have covers, vapor collection systems, or floating roofs. Hydrocarbon emissions from these sources are presently 3 tons daily. One of the large installations of this type, now controlled by floating roofs, formerly emitted 40 tons of hydrocarbons daily.

Loading racks are another source of hydrocarbon emissions for which regulations now exist. These are the facilities for filling tank trucks with gasoline and other products for delivery to service stations or commercial accounts. Formerly, the vapors displaced when the trucks were filled went to the atmosphere. These vapors are now recovered and returned to the products being loaded or they are burned as fuel.

Other sources of hydrocarbon emissions in refineries include leakage from valves, pumps, air blowing of stocks, blowdown systems, pipeline blind changing, and compressor engine exhausts. Operations such as shutting down equipment for repairs may give rise to hydrocarbon emissions. These emissions are usually reduced to low levels by venting to recovery systems before opening vessels for maintenance work.

Emissions of contaminants other than hydrocarbons, such as oxides of nitrogen, sulfur dioxide, and sulfur trioxide, arise mainly from combustion sources. Sulfur dioxide has been controlled to the extent of over 600 tons daily in Los Angeles County by removing hydrogen sulfide from refinery gases before they are used as fuel.

Emissions of smoke from boilers and heaters can be quite readily controlled by use of proper equipment and operational procedures. It is now extremely rare to see smoke issuing from a refinery stack.

Emergency flares for disposing of large quantities of gas by burning are now all designed for smokeless burning. This is accomplished by venturi-type burners, or by steam injection.

Summary

In conclusion, there are 18 oil refineries in Los Angeles County, with a total daily throughput capacity of over 700,000 barrels of crude oil. These refineries emit daily to the atmosphere approximately 100 tons of hydrocarbons, 150 tons of sulfur dioxide, 60 tons of oxides of nitrogen, and lesser amounts of other contaminants.

These emissions are close to the practical lower limits which can be achieved. The refineries have installed control equipment on all sources for which practical methods have been devised. Refinery personnel are very conscious of the necessity to carry out operations in a manner to minimize emissions.

The enforcement arm of the Air Pollution Control District carries out frequent periodical inspections of all refinery units to check on the condition of control equipment and maintenance of operational equipment to prevent leakage.

The losses to the atmosphere from Los Angeles refineries in all likelihood are not representative of losses from refineries in other parts of the country. Other refineries can be expected generally to have significantly higher losses. The two important factors contributing to this condition are (1) the stringent regulations adopted in Los Angeles County, and (2) the strict self-policing of operations by Los Angeles refineries to keep emissions at a minimum.

Even with installation of all known control measures in a modern refinery, the rate of emissions of air contaminants can vary widely, depending on the maintenance and operational procedures applied to prevent escape of hydrocarbons and other compounds. Where an area is subject to accumulation of air contaminants, and has an important oil refining industry, unceasing effort is needed to keep the emissions at tolerable levels.

DISCUSSION

Floyd Parslow. My problem is on paint deterioration. I have two homes affected; the paint turns black in newly painted houses and then turns a purplish color.

Mr. Fisher. That is apparently from hydrogen sulfide in refinery gas. Obviously, if you have a refinery that is emitting gas that contains hydrogen sulfide and you have, particularly, white painted houses in the area and if it's a lead-based paint, you are going to have the houses darken because of the lead sulfide, which is black. That is a problem all refineries have had at one time or another. You must control your hydrogen sulfide mixes and until that is taken care of by removing from the refinery gases the hydrogen sulfide, which is subsequently converted into sulfuric acid, you will have that problem.

(UNIDENTIFIED). In that problem of the paint, what about a solution by using some paint that doesn't have lead in it?

Mr. FISHER. You will still have the odor, but your paint will not darken.

(UNIDENTIFIED). Do you get complaints on odors as well as on darkening?

Mr. FISHER. If you have any appreciable amounts of hydrogen sulfide released you will get complaints.

Industrial Sources of Air Pollution (2)—Electric Power Plants (Gas and Oil Fuels)

Dr. Arie J. Haagen-Smit
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California Institute of Technology
Pasadena, Calif.

W. L. Chadwick
Vice President, Southern California Edison Co.
Los Angeles, Calif.

(Read by A. C. Austin)

Our part of this program is to discuss one of the sources of air pollution, namely, that caused by the combustion of natural gas and fuel oil as a part of the process of producing electric power. It will be an aid to our discussion, however, if we may first set the amount of such combustion into the framework of the total use of fuel in the country. U.S. Bureau of Mines statistics show that during the year 1957, the United States burned for all purposes 444 million tons of coal, 505 million tons of liquid petroleum products, and 254 million tons of natural gas. Of these totals, 37 percent of the coal, 2.7 percent of the petroleum products, and 13.2 percent of the natural gas were used for electric power production, or about 15 percent of the total fuels were burned for this purpose. These values are probably a fair measure of the relative amounts of the total combustion gases produced. Of the electrical energy produced in the United States during 1957 by thermal stations, approximately 69 percent was produced from combustion of coal, 8 percent from combustion of fuel oils, and 23 percent from combustion of gas. Because it is not relevant to this discussion, the production of electric power from waterpower is disregarded.

Our discussion will be limited to an even smaller portion of this total combustion, however, inasmuch as it concerns what has been found out about the control of air contaminants resulting from the combustion of fuel oil and natural gas for electric power production in the Southern Coastal basin of California.

Most of you are already familiar with the physiographic setting of the Southern California Coastal basin and with its unusual meteorology. Here, for part of the year, inversion layers, at varying levels, act as lids to confine combustion products and deter dispersal. Mountains on two sides and cold air from the sea complete the confinement. Within this confined space live about 6 million people, owning 3 million automobiles, and supported by about 15,000 industries.

Air pollution first became a problem in the Southern California area with the stepped up population and industry which occured during World War II. The conditions which caused it were not understood for some years. In 1951 Dr. Haagen-Smit proved that the reaction of unburned hydrocarbons and nitrogen oxide in strong sunlight produces the characteristic conditions now known as Los Angeles smog. Previously sulfur products had been the most suspect and much was done by industry to reduce these products. With an understanding of the basic chemical reaction, the drive then was to control hydrocarbon releases and much was done toward this end.

In 1947 a regulation was adopted which undertook to regulate air pollution from industry by declaring that any stack plume which was as dense as Ringelmann No. 2 for more than 3 minutes in any hour is in violation. In 1955 several power installations aggregating 1 million kw. were denied permits to construct, or to operate, because it was charged that when burning fuel oil the plants would periodically violate the regulations. Control regulations set 0.2 percent by volume of sulfur, measured as sulfur dioxide, as the allowable release from a stack and not over 0.3 grain per standard cubic foot as the limit for dust. Typical experience shows that when commercial fuel oil which is bought to specification is burned, sulfur products reach about one-half this allowable, with dust about 15 percent of the allowable. Accordingly, powerplants found it not difficult to operate within the sulfur and dust regulations, but at times, dependent upon several variables, the Ringelmann No. 2 requirement could not be met. As a result, because no one wished to curtail the production of electric power and hence be responsible for the losses of the public which would then obtain, hearings and variances became necessary.

The whole field of powerplant air-pollution control was relatively unstudied, except for the separation of heavy particulates. The problems of particulate separation from fuel oil combustion gases, however, are quite different. Some intensive study and research were indicated. A beginning was made by individual companies in 1954. In order to intensify efforts in this direction, a Joint Research Council on Power Plant Air Pollution Control was formed in March 1956. This council consists of scientists, engineers, and technicians from the various agencies in Southern California which are concerned with the problem. The original member agencies were the Air Pollution Control District of the County of Los Angeles, the Department of Water and Power, City of Los Angeles; the separate electric departments of the cities of Pasadena, Glendale, and Burbank, and the Southern California Edison Co. The Air Pollution Control Districts of Orange, San Bernardino, and Riverside Counties, and the California Electric Power Co., were added subsequently as associate members. The principal purpose of the council is to exchange, at the earliest time possible, all results of air-pollution control investigation and research and so to aid each investigation and each user member as early as possible, with any findings of an associate. All research activities are undertaken, carried out, and fully financed by the individual member agencies, but data and results are freely exchanged for the common good. A most important policy of the council is that there be the freest exchange of pertinent technical information between all council members, but that this information be considered confidential within the council until such time as findings warrant announcement, yet without limiting in any way the common effort to solve air-pollution problems. The council has functioned effectively.

The investigations and research of Southern California Edison Co. as a part of this joint program have been carried out under the direction of the authors.

Because of the problems related to plume opacity, some of the earliest efforts were directed toward its reduction. Although the physics of this phenomenon are still not fully understood, it is generally agreed that plume opacity is affected significantly by particulate matter; by the small amount of SO_3 present in the stack effluents, as well as by the water vapor present; by ambient atmospheric conditions; by the angle of illumination; and by the kind of background against which the plume is observed.

The first effort was to reduce the particulates. Particulates from fuel oil combustion are microscopic in dimension, and the quantities produced are small when compared with those produced by burning the better coals. The order of size is about 0.4 micron. The amounts of ash in fuel oils vary from about 0.05 percent to 0.15 percent by weight. Proved devices to remove such particulates were not available. Mechanical collector-electrostatic precipitator combinations had, of course, been developed, which are effective in removing the heavier fly ash particulates which are present in discharges from coal-burning plants. Such collectors did not appear suitable for the particulates and for the low loadings in oil fire effluents. These loadings show total particulates of about 75 pounds per hour from a 175 MW unit at full load. Further, the manufacturers of conventional control equipment were not themselves interested in spending the sums required to develop equipment for such a limited market as appeared to exist. Hence, it was necessary as a part of its research program for Southern California Edison Co. to buy much of the required pilot plant test equipment and to carry the bulk of the testing and cost of manufacturer's research and development work.

One of the early research and development problems related to all the investigations here discussed was to select analytical methods which would give reproducible results under similar circumstances and which would be accepted by all authorities. This selection involved proving methods for measuring (1) the particulate content of a gas stream, (2) the sulfur dioxide content, (3) the sulfur trioxide content, and (4) the nitrogen oxide content. At the outset, authorities differed widely on analytical methods and no standard tests existed. Because of unsatisfactory analytical methods, some early results were deceptive and led to early hopes which could not be supported when the errors of analysis were removed. One illustration of the breadth of disagreement at the outset is the spread of the results obtained for nitrogen oxide content of the same gas stream. One method would show around 20 parts per million, the other nearer 500 parts per million. A hard working group of analysts and specialists comprising a Task Force on Analytical Methods has selected techniques which now give reproducible results and data which are acceptable to all parties. The following are the methods being used:

Particulates—Blackness test:
SO_2—Hydrogen peroxide—barium sulfate method.
SO_3—Barium sulfate method.
NO—Phenoldisulfonic acid method.

Two pilot-scale precipitators utilizing two differing precipitation principles, and designed by separate manufacturers, were built and put under test on a bypass from the actual gas streams of the 175,000 kw. operating units at the El Segundo station. After a test and development program which required more than a year, at a cost of approximately $500,000, the design criteria for full-scale precipitators for use on fuel oil effluents were established.

These criteria indicated that about 90 percent of the loading, of which more than 90 percent is below 0.5 micron, could probably be satisfactorily removed. Proposals were invited from each of two cooperating manufacturers and a selection was made. The resulting precipitator is now being erected with the anticipation that it will be under test in full-scale operation by January 1959. It is being erected at the El Segundo Steam Station on a boiler supplying steam to a generating unit of 175,000 kw. operating capacity. This precipitator, which has a guaranteed collection efficiency of 90 percent, is similar to those which have been used elsewhere in conjunction with mechanical collectors to obtain a collection efficiency of 97–98 percent on coal fired boilers. The prototype will have a gas velocity of about 7.3 feet per second, and a treating time of about 2.5 seconds. The general arrangement is somewhat unusual and expensive because it is being adapted to an existing generating unit instead of being engineered into original construction. Further, the insulator compartments are somewhat more elaborate than would be expected on a similar unit for use with coal firing because oil fire gases seem to cause heavier insulator fouling. Also, the lower dust loading and the nature of the dust itself have resulted in a different collecting system and hopper arrangement from that which would be provided for fly ash. It is expected that the total cost of manufacturing, erecting, testing, and perhaps post-operating modifications of the precipitator will be about $1 million.

A pilot-scale bag installation, filtering part of the stack gas from an operating unit, is being used to test the collection efficiency and performance of such devices. Bags of siliconized glass cloth and of other materials are being tested. As much as 99 percent of the particulates from oil fires have been collected on some of the tests. This investigation is continuing, but preliminary appraisals indicate that the comparatively high pressure drop through the bags and the physical size of a full-scale installation may make collectors of this type impractical.

Early results before refinement of the analytical techniques indicated a possibility that some of the sulfur products in stack gases might be brought down in the precipitator with the dust. After refinement of test methods, however, this proved to be a false hope, that is, without additives. Some of the literature indicated possible aids here and they were tried. All early efforts in this direction, however, were severely handicapped by the lack of a satisfactory method for measuring SO_3 concentrations in the presence of the alkaline additives. With the commonly used techniques, it was impossible to determine whether unreacted alkaline additives were drawn into the analytical apparatus and hence, whether they interfered with the test reactions. A dew point method was finally developed which appears to have overcome this difficulty, but only at the expense of considerable time and effort.

In the first work on additives, solid, finely ground (325 mesh) limestone, calcium oxide, calcium carbonate, and dolomite (approximately 60 percent magnesium carbonate and 40 percent calcium carbonate) were used. These solid additives were first injected into the gas streams, ahead of the precipitators, at points where the gas temperatures were about 700° F. and 300° F. No appreciable lowering of the SO_3 concentration was obtained with any of the materials injected at these points. However, an extended investigation has been made of the effect of injecting dolomite directly into the furnace. This test had two objectives, (1) that of determining the effect of the additive on the nature of the boiler tube deposits, and (2) that of determining the effect on the formation of SO_3. The results of this work show that when the dolomite is added at a rate which would theoretically react with about 10 ppm of SO_3, the SO_3 is reduced somewhat more than one-half, that is, from an average concentration of 13.1 ppm to 6.1 ppm.

Tests were also made of the effect of the addition of gaseous ammonia to the stack streams. The results of this work show that when the ammonia was added, stoichiometrically either at the 700° F. point, or at the 300° F. location on the gas stream, there appeared to be nearly complete reaction with the SO_3, and hence, complete removal. On the other hand, it was found that if ammonia gas is added in quantities substantially greater than the stoichiometric amount, the SO_3 would also be removed, but a detached dense white plume was formed at the discharge from the precipitator. This plume appears to result from a reaction between the ammonia and SO_2, the product of which seems to remain in a gaseous phase at the temperatures obtaining in the precipitator, but which precipitates when the temperature is lowered on diffusion. The resulting dense plume is of course objectionable. This reaction and phenomenon is being investigated further.

During the early investigations, literature research and industry conferences in large number were carried out to determine whether it was economically feasible to remove in the refinery the compounds which cause the sulfur and nitrogen oxides, that is, before the fuels were pumped to the powerplants. Extensive investigation determined that the refinery industry has had this problem from its beginning, and that it has so far been unable to develop a process for such removal which is economically feasible. Methods are known, but so far, none which has come to the authors' attention permits producing a fuel through its use without prohibitively increasing the cost of electric power.

Extensive study has also been given to the possibility of obtaining fuel oils of low sulfur product content. This search proved that it is not feasible because, (1) fuel oils are the result of refining many crudes from many fields, all differing to some extent, (2) while some crudes may be found with sulfur products as low as 0.1 percent, they are not common in occurrence, and are unusual among asphaltic base crudes, (3) many of the heavy crudes which yield the highest amounts of fuel oil have sulfur contents of from 2 percent to 5 percent, and (4) Southern California is indigenously an asphalt-base oil producing area, and hence, its crude oils are not preponderantly those of low sulfur content.

Concurrently, extensive literature review was carried out searching for means of reducing sulfur and nitrogen compounds in the stack gases produced by burning fuel oils.

Coauthor Haagen-Smit in particular carried on the research seeking ways and means of reducing sulfur and nitrogen compounds in stack gases. This work covered a period of more than 2 years and involved an intensive bench scale study of adsorption, and of catalytic conversion methods. Three different catalysts were tried comparatively; these were Harshaw vanadium catalyst, treated dust from one of the pilot plant precipitators, and Monsanto vanadium catalyst. The latter was found to have an efficiency of 90 percent in oxidizing the SO_2 in flue gas at 900° F. No significant reduction in the NO in the flue gas was effected by these catalysts unless ozone was added after the gas had passed the catalyst bed. After such an addition, up to 90 percent of the nitrogen oxide could be removed by the pilot plant precipitator. This work was supplemented by tests on a larger catalyst bed. Here at a flow rate of 3.5 to 4 cfm of flue gas, a bed containing 110 grams of Monsanto vanadium catalyst at 900° F. almost completely converted the SO_2. The SO_3 could then be precipitated at 300° F.

This work led to the conclusion that a process is technically possible which will remove approximately 75 percent of the nitrogen oxide and about 90 percent of the SO_2 from fuel oil flue gases if they are passed through a vanadium catalyst at high temperature, followed by the introduction of ozone and electrostatic precipitation. Independent estimates for a full-scale operation, however, showed the process to be infeasible economically.

The studies on adsorption embraced 150 experiments on a bench scale using 15 different grades of charcoal supplied by three different manufacturers. Two lignite charcoals were used through cooperation of the U.S. Bureau of Mines. The first work was directed toward determining the breakthrough point for SO_2, that is, the number of cubic feet of flue gas which could be passed through the adsorption bed before SO_2 could be detected in the effluent. One of the most promising charcoals tested showed that after 51 consecutive adsorption-desorption cycles, the charcoal would still adsorb 8 percent of its weight in SO_2 at 150° F., a value very close to that obtained at the start of the test. A 20 percent loss in weight was noted in the charcoal during the term of the test. This work indicated at an early stage that the efficiency of nitrogen oxide adsorption was significantly lower than that of SO_2 adsorption. Later work indicated that the nitrogen oxide was adsorbed first, and later displaced as the SO_2 breakthrough point was reached. Following these studies, a consulting chemical engineer was employed to prepare flow sheets and estimate the cost of a plant which might perform equal results full-scale. Unhappily, these estimates showed prohibitive costs, ranging from a low of $57 to $285 per kilowatt of station capacity.

As the chemical studies proceeded and the economic difficulties in operating any such process at full scale became evident, ways and means of avoiding, or of significantly reducing, the formation of nitrogen oxide were sought so that hopefully its reduction by chemical processing might not be necessary. It was considered that perhaps the boiler furnaces available in Southern California might comprise a large laboratory equipped with furnaces of differing designs, differing firing patterns, and differing configurations, which might significantly affect flame temperatures and hence, the formation of nitrogen oxide. Accordingly, an extensive set of tests was made on 9 different boiler furnace designs in Southern California and through the cooperation of the manufacturers on 13 furnaces of differing designs elsewhere in the United States. By this means flame conditions and nitrogen oxide formation were observed for some 22 furnace patterns, and for 3 fuels, that is, fuel oil, gas, and coal. The results, when burning fuel oil under full load conditions, vary from a low of about 330 to a high of 915 ppm. The lower results were for a furnace using a protracted combustion path and the higher one for using a contracted path. The results obtained for gas operation varied from a low of 160 to a high of 1350 ppm. The low reading was obtained on the same boilers which had shown the lowest formation of nitrogen oxide when burning fuel oil. The highest readings were for a Midwest furnace which was front-fired. At the present time the reason for the very high nitrogen oxide formation on this boiler is not fully understood. One possible explanation may be high nitrogen in the gas itself. These high readings are not believed to be erratic observations, because readings of 1,200 ppm were obtained on another boiler in the South, also while burning gas fuel; and an observation of 970 ppm was obtained on a third boiler in the Midwest, also with gas fuel. The nitrogen oxide results obtained while burning coal varied from a low of slightly less than 650 to a high of 1,460 ppm. With these results, studies were undertaken in cooperation with the manufacturers to determine what might be done through varying boiler designs, firing patterns, combustion-air introduction, or otherwise, to lower nitrogen oxide fromation. This work required many additional tests. In all of the tests conducted, the same methods for nitrogen oxide determination were used. Where work was done by the manufacturers, their representatives verified the method used by the Edison investigators and most of the tests were observed both by representatives of the affected manufacturer and by an outside laboratory retained by Southern California Edison Co.

The results of these tests confirmed that the rate of nitrogen oxide formation is dependent upon the temperature of combustion and suggested that it is affected by the way in which combustion-air is introduced, that is, by its turbulence, its pressure, its proximity to the burner where the fuel is introduced, and by the completeness of combustion-air delivery immediately at the burner. Flame temperatures were also found to be influenced by the mutual radiation of associated burners. This conclusion was reached after comparing results from varying the firing patterns for multiple burner arrangements.

Full-scale tests have been conducted on burners at El Segundo Steam Station to determine the differences in nitrogen oxide formation which occur when the introduction of combustion-air is delayed, that is, where 95 percent is introduced at the burner and the remainder of that required for complete combustion, and all excess, is introduced farther along the flame. This work included modifying the rear wall of a front-fired furnace to introduce secondary combustion-air in that wall and alternatively to introduce all secondary air about the burners in the front wall. Introduction of secondary air in the rear wall showed a low reduction in nitrogen oxide formation, probably because the cold air introduced was heavy enough to move down the introduction wall to the floor of the furnace and up the front wall rather than to move directly across from the introduction port to the burner. Results from secondary air introduction above the burners show reductions in the order of about 40 percent. New boilers are being purchased with secondary air introduction. This nitrogen oxide work is continuing, but so far it is believed to have produced greater tangible benefit in air-pollution control than anything else so far tried in the associated research. It is believed that eventually it may be possible to so modify boiler designs that nitrogen oxide formation, either when burning oil or burning gas, may be reduced to not over one-half of what would otherwise result. At the outset of this work, it was thought that combustion efficiency might be lost in controlling nitrogen oxide but fortunately this fear proved groundless.

One interesting corollary of the work which has been done on the sulfur and nitrogen oxide removal has been the development by Beckman Instruments of an infrared gas analyzer which permits the continual recording of sulfur dioxide and nitrogen oxide levels in a furnace. Development of this instrument has been most gratifying. Another corollary of the work on nitrogen oxide has been the observation under certain flame conditions that some carbon monoxide can be formed in a furnace even though the combustion temperatures are normally high and combustion is efficient. Carbon monoxide levels in excess of 100 ppm have been observed. This detection requires better instruments than usually are used in power stations. Careful analysis of the conditions under which this monoxide was formed indicate that the operating conditions were not normal or it would not have formed.

Most of the foregoing concerns the minimization of air contaminants from the burning of fuel oil. Early during the research program, it became clear that the burning of natural gas would produce no particulates and almost no sulfur oxides and probably, under most conditions, a lower level of nitrogen oxides. Thus, three of the four principal contaminants produced by burning fuel oil might be avoided if sufficient natural gas could be obtained for replacement. This ideal situation however, had never proved practicable previously, because of the interruptibility of natural gas for household and other heating use. Replacement with fuel oil became necessary. Intensive efforts have been made, however, to importantly increase the supply of natural gas available for power generation as an aid to minimizing air pollution. Much time is required for any such project, however, because of regulatory lags and opposition. Progress is being made in efforts to obtain firm supplies for power generation.

In concluding this paper, it is desirable to point out again that although intensive effort has been applied, (1) to minimizing the particulate matter emitted from furnaces while burning fuel oil; and (2) to reducing sulfur compounds, particularly the SO, the writers as yet know of no data which would indicate that there has been any harm resulting from the particulates. It is believed that the small amount of SO can be importantly reduced, perhaps even entirely eliminated, but there is still controversy among the authorities as to danger resulting from existing SO_2 levels in an atmosphere which is high in nitrogen oxides and ozone.

Practicable ways and means are available for reducing particulates, sulfur trioxide, and nitrogen oxides from fuel oil combustion, and industry in the Southern California area is exerting itself fully and productively toward minimizing the effects of air pollution which it may cause, while waiting for the automobile, the greatest producer of unburned hydrocarbon and nitrogen oxides, to be put under control.

The authors wish to acknowledge the work and cooperation of Dr. C. L. Ruby of California Research Corp., of the Bechtel Corp., of Truesdail Laboratories, of Babcock & Wilcox Co., of Combustion Engineering Co., of Standard Oil Co. of California, of H. C. Austin, and of other members of the Joint Research Council on Air Pollution from Power Plants.

DISCUSSION

(Unidentified). Please tell us a little more about the method of air introduction so as to reduce NO in boiler design when firing either with gas or oil.

Mr. Austin. We are still experimenting on this. One of the first things we found was that in our power station boilers, quite a bit of the design has been for the benefit of the operating men's opinion only. The operating men like to see a short, violent, hot flame. Boiler designers don't necessarily need that type of design.

By producing some of the little details such as vanes which are used to reduce turbulence in the combustion air stream, by lowering the pressure of the air introduced from the wind box into the burner, we were able to achieve some results. However, the greatest result was achieved by use of supplementary combustion air. This has not been announced generally but in effect, what we have done is to put in supplementary air above the burners and reduce the amount of combustion air through the regular burners to about 95 percent of theoretical and introduce the remaining 15 percent above that. We have had reductions of as high as about 43 percent just by that one device alone without any significant reduction in furnace efficiency and still no trace of combustibles in the stack. We expect its efficiency, guaranteed efficiency, to be 90 percent for particulate matter. Just recently we have developed some information and it appears that there may be a wide range of particulate sizes from oil furnaces. It seems that in some furnaces 83 percent or more of the particulates are above 5 microns. Our experience is they are in a submicron range.

Frank J. Holland. If it was possible that all carbon in the fuel could be combusted or if something should happen in the boiler that there would not be any free carbon to adsorb the sulfur, what would happen to the sulfur? Would that be a dangerous element being spewed out in the air as sulfur is released from your fuel that didn't have anything to adsorb to, to collect to? What would happen? I contend that if there was no free carbon left in the boiler after combustion, there wouldn't be anything to adsorb or to allow sulfur to concentrate on.

Mr. Austin. That is a little beyond my field. I would like to point out that all our indications are that we have a very small amount of carbon in the discharge from our furnaces. We cannot detect combustibility with the ordinary means.

I recently checked the ash analysis we made from the particulates we have collected from our boilers, and the unburned carbons runs far less than 1 percent of the ash and the ash itself is very small. My understanding is that practically all the gas goes out in the form of sulfur dioxide with a very small amount of sulfur trioxide. Many of the gentlemen here are far better qualified to speak on that.

We get a certain amount of sulfation. Most of the metallic elements in our ash are in sulfate form, but that represents a very small part of the total sulfur found in the fuel, I believe.

Dr. Chambers. Indications are that the amount of free carbon particulate matter under these high temperature conditions is extraordinarily small. There is particulate matter but the formation of sulfur dioxide and subsequent possible formation of sulfur trioxide and sulfuric acid, I think, is in a way dependent on the presence of carbon.

Granville Williams. Did I understand that you are experimenting with the burner and that your experimentation was with 95 percent of the primary air mixed with the fuel in the burner and 15 percent over the burner port?

Mr. Austin. That's correct. It happens on many types of burners that there is a very close intermingling in the burner. We don't claim to eliminate it but we reduce the oxides of nitrogen significantly. There are other types of burners that get good combustion in the furnace where you find no trace of combustibles that do not mix the air as intimately in the burner throats and still achieve perfectly good combustion, with lower point temperatures in the flame.

(Unidentified). Is it your opinion now that the lower the maximum flame temperatures are the less will nitrogen be oxidized?

Mr. Austin. Very much so and the few observations we have made support that. We do not know of any measure that will accurately measure point temperatures in the flame but all the common methods seem to indicate that as we get a trend of lower indicated temperatures, we get a reduction in NO.

Industrial Sources of Air Pollution (3)—Electric Power Plants (Coal Fuel)

Arthur A. Orning
Chief, Combustion Section
U.S. Bureau of Mines, Pittsburgh, Pa.

Emission of obnoxious gases and dust from coal-fired electric powerplants depends upon the coal and the design and operation of the equipment. If products of incomplete combustion, such as smoke and organic gases, are emitted, they are the result of faulty design or poor operation. Their amount will vary widely with combustion conditions. We may assume that no significant quantities of these products are emitted from well-designed and properly operated coal-fired electric powerplants.

Emission of dust and oxides of sulfur depends upon the mineral matter and sulfur content of the coal and the control measures provided in the plant. Typical analyses of coals of the United States are available.[1] *Figure 1* was given by Rose[2] on the basis of these

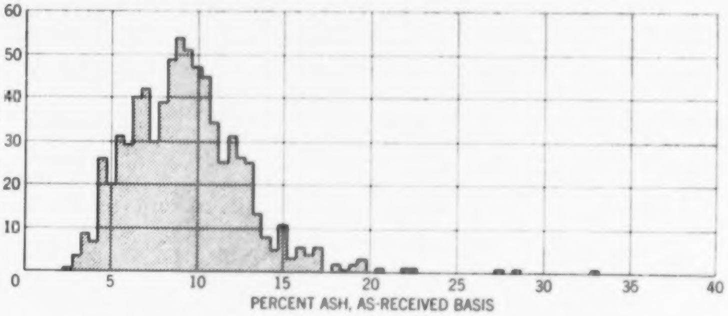

FIGURE 1.—*Ash contents of typical coals of the United States.*

analyses. Based on a comparison of these with more recent analyses of tipple and delivered samples obtained in relation to purchases of the Federal Government,[3] Rose concluded that the data apply also to coals being produced and marketed in the United States.

The distribution of coals according to ash content, as given in *figure 1*, is not adjusted in proportion to production. Tabular data on this distribution are not available for coals used by electric powerplants. Premiums are seldom paid for coals of low ash content for production of electric power, although exceptions to this are becoming more numerous. Considering these facts, an average higher than that indicated by *figure 1* should be taken. A nominal value of 10 percent ash content would therefore be a reasonable estimate for the average for coals used for electric power production in the United States.

Coal consumption for generation of electricity is shown in *figure 2*, based upon U.S. Federal Power Commission Monthly Reports. The seasonal variation is shown by *figure 3*. Based on incomplete data, the consumption for 1958 may be about 5 percent less than that indicated for 1957. The consumption has nearly doubled in the last 10 years and may be expected to do so again in the next 10 years.

Most of the ash from the coal used is collected; the remainder passes to the atmosphere through stacks. On its own initiative the industry has installed dust collectors and can comply with legal controls within practical limits.

Published data on dust emission are scattered and vary widely. Incidental to an investigation of germanium in coal ash,[4] dust emission

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[1] Fieldner, A. C., Rice, W. E., and Moran, H. E., U.S. Bureau of Mines Bull. 446 (1942).

[2] Rose, H. J., Percentages of Ash, Total Sulfur and Sulfur Forms in U.S.A. Coals. Paper presented before the Division of Gas and Fuel Chemistry, Am. Chem. Soc., Annual Meeting, Chicago, Ill., September 7–12, 1958.

[3] Aresco, S. J., Haller, C. P., and Abernethy, R. F., U.S. Bureau of Mines, Rept. of Investigations 5332 (1957).

[4] Corey, R. C., et al., Occurrence and Determination of Germanium in Coal Ash from Power Plants. U.S. Bureau of Mines, Rept. of Investigations, in publication.

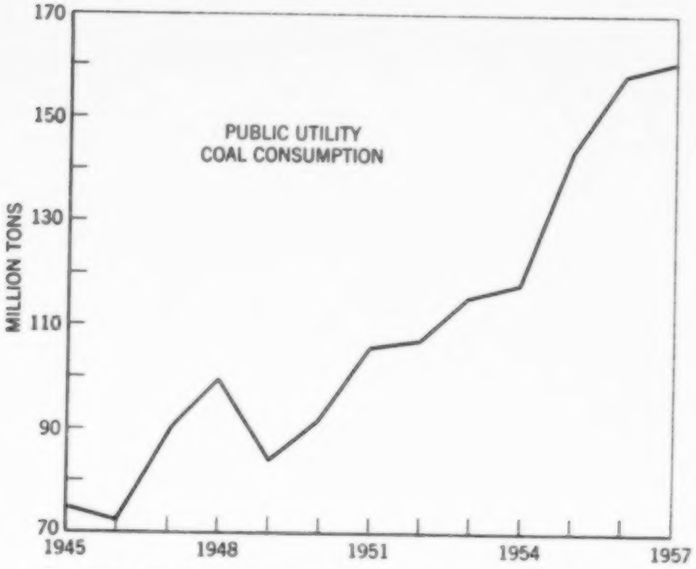

Figure 2.—*Public Utility coal consumption in the United States.*

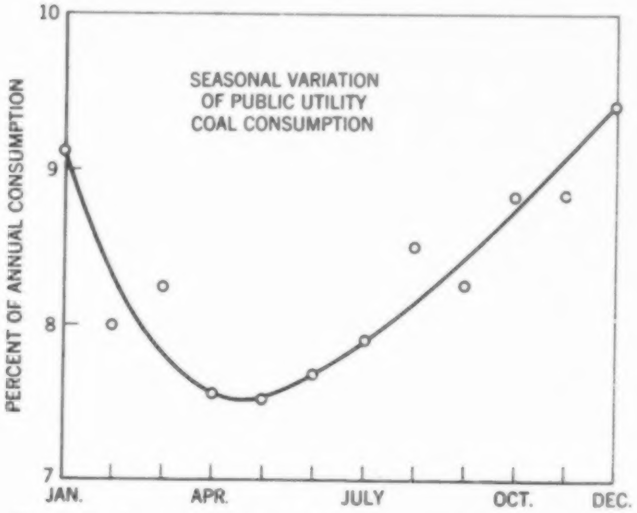

Figure 3.—*Seasonal variation of Public Utility coal consumption.*

was determined in a number of powerplants and could be calculated as a percentage of the weight of ash in the coal used. In an isolated pulverized-coal-fired plant with no dust-collecting equipment the percentage was about 80. Plants with mechanical and electrostatic dust collectors showed 10 to 20 percent. The percentage also depended upon the type of combustion equipment. It was generally lower with stokers than with pulverized coal firing. A plant that was firing crushed coal in a cyclone combustion chamber and using an electrostatic precipitator showed a low value (2 percent). To approximate total dust emission we may assume, for lack of better knowledge, that 10 percent of the ash in the coal will appear as dust entering the atmosphere. At present, based on this assumption, total dust emission for the United States from electric power production varies from about 4,000 tons per day in the summer to 5,000 tons per day in the winter. The emission in any given area will depend upon industrial concentration and local control of air pollution.

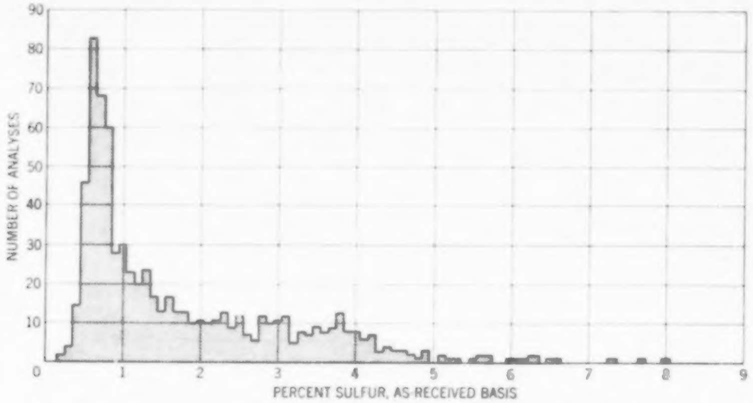

FIGURE 4.—*Sulfur contents of typical coals of the United States.*

The dust may contain 10 percent or more of carbon, but demands for more efficient power production have pushed down and will continue to push down this percentage. The ash is composed primarily of oxides, complex silicates and aluminates of iron, calcium and magnesium with small percentages or traces of sodium, potassium, chlorine, phosphorus, sulfur, and other elements. Particle-size analyses have shown 50 percent by weight to be finer than 10 microns and 90 percent finer than 30 microns. A large percentage of the dust particles is spherical, but some are sharp and angular, showing no sign of fusion.

The sulfur content of typical steam coals varies more than the ash content. The distribution of sulfur content, shown in *figure 4*, was obtained from the same source and has the same limitations as given for *figure 1*. The large number of samples having a sulfur content less than 1 percent is in part a result of the search for low-sulfur coals for metallurgical cokes. For reasons similar to those given in relation to the ash content, the low-sulfur coals may be ignored and a nominal value of 2.5 percent may be taken as the average sulfur content of coals used for electric power production in the United States. This value may be high in the Appalachian and low in the midcontinent region. Under special although not generally practicable conditions, a large percentage of sulfur can be held in the ash; however, the sulfur in the ash, expressed as a percentage of the weight of ash, will generally be equal to or less than the percentage of sulfur in the original coal. For a coal of 10 percent ash content, 90 percent or more of the sulfur may appear as oxides in the combustion gases. About 1 to 2 percent of the sulfur oxides may be present as sulfur trioxide. The exact percentage will depend upon combustion conditions, catalytic action of dust and metal surfaces, and absorption of the trioxide if condensation of acid and water has occurred on colder heat-transfer surfaces. The best approximation that can be made is that most of the sulfur in the coal will appear as sulfur dioxide with a small variable percentage as the trioxide. Using the data on coal consumption and sulfur content and assuming 90 percent release, we can estimate that the total tons of sulfur emitted per day as oxides from electric powerplants in the United States vary from about 9,500 tons in summer to 12,000 tons in winter.

Processes for removing sulfur oxide from combustion gases have not been used in this country. Experience in England has shown that the cost of removing the sulfur oxides by known processes is so high that they will not be employed except under most compelling circumstances.

Although many data are available on emission of dust and sulfur dioxide, little if anything has been published on oxides of nitrogen from coal-fired electric powerplants. Thermodynamic equilibria are such that nitrogen dioxide cannot exist at the high temperatures in a large coal-fired furnace. However, a study of the equilibria in combustion gases at high temperatures[5] has shown that nitric oxide, NO, can be present. *Figure 5* was drawn from data used in this study.

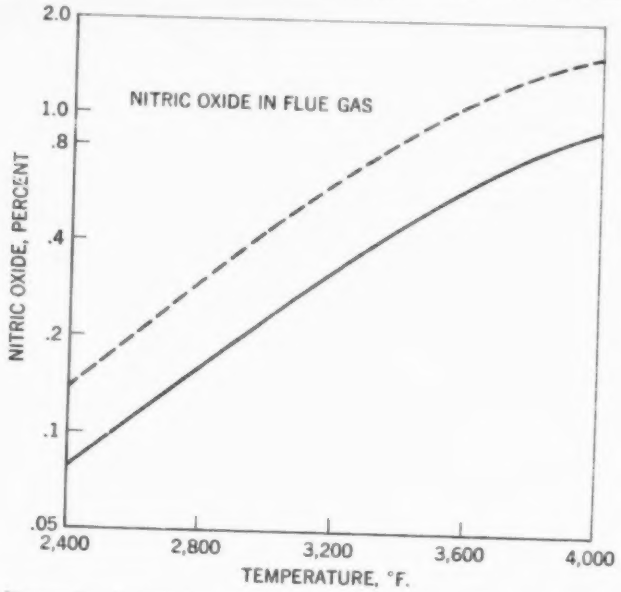

FIGURE 5.—*Equilibrium concentration of nitric oxide in flue gas.*

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[5] Myers, J. W., et al., Calculation of Theoretical Flame Temperatures in Furnaces. Trans. Am. Soc. Mech. Engrs., *80*, 202–16 (1958).

The solid line, showing the equilibrium percentage of nitric oxide as a function of temperature, is approximately correct for any bituminous coal burned with 20 percent excess air. The dotted line shows the effect of increasing excess air to approximately 100 percent, if the temperature could be held constant. Since increased excess air decreases furnace temperatures, the content of nitric oxide may decrease with increased air under operating conditions.

Gases leave the primary furnaces of large steam boilers at temperatures on the order of 2,000° F. and are cooled rapidly as they pass through the boiler. If equilibrium is attained in the furnace and decomposition avoided by rapid cooling, concentrations on the order of 0.1 percent nitric oxide, 1,000 ppm, may occur in the flue gases. Published data are needed to support this conclusion.

Published data on emission of minor coal constituents, such as chlorine and fluorine, are too meager to be of value. These elements are found in the residual ash, but a part of that present in the coal probably is released to the atmosphere.

Knowledge of the end products of combustion and measurement of amounts of individual components of the fuel held in ash residues are useful tools for estimating the remaining products that are carried into the atmosphere and may be air pollutants. This procedure would be improved if data on coal consumption for electric power production included data on the ash and sulfur content. Additional information is also needed on emission of pollutants related to the design of equipment, the conditions of operation, and the analyses of the coals used. The cost of collecting such data must be considered in relation to our need for more precise information on sources of air pollution than may be deduced from average coal analyses and knowledge of combustion processes.

DISCUSSION

Dr. Maurice Kamp. Are there any ways of treating high sulfur coal so that it can be used and still be economically feasible?

Dr. Orning. Of course, the coal preparation can be improved somewhat at a cost to reduce some of the ash content. For instance, some of the sulfur is present as a separable component, pyrites, in many coals. It cannot be eliminated. You can reduce it somewhat, at considerable cost, by washing techniques.

Where mechanical mining has considerably increased the ash content, there has been a tendency in coal preparation to bring that back to what it might be by methods of hand mining. To carry it on much further than that involves considerable increase in the cost of the fuel and considerable loss of fuel in the material discarded from the washer. There is no complete elimination as yet.

Mr. Rehm. We heard yesterday the descriptions of the potential use of fly ash material in the construction industry and various others. Do you feel that the economic impetus gained by the use of this material in this field will mean that it will eventually help in the collection of this material?

Dr. Orning. There is some considerable usage, but I am talking about 17 millions of tons. This is not going to be a very important factor except under very local conditions.

Professor CHANLETT. Might it not be useful to have a summary of oxide formation in terms of fuels, temperatures, and pressures, because as we get it piecemeal, the story of oxides, gas fired, oil fired, oxides of nitrogen, you get a mixed picture. I wonder if we can have a clarification of what these relations are.

Dr. ORNING. Temperature is one of the most important things and part of what Mr. Austin was talking about—the manner of admitting air to his furnace—involves the peak temperatures produced in the furnace. I think the temperatures are by far the most important.

You may recall that on my graph (indicating *figure 5*), I had a dotted line above the solid line. The solid line will correspond to bituminous coal under fairly normal conditions of operation. The dotted line would apply at the same temperature, which you might not obtain with a higher air pressure, going up to maybe 100 percent excess air. It depends on the fuel used, temperatures, etc. There is some talk of using a higher pressure furnace for power production purposes. This is dreaming at the present time. It may happen. It is, of course, involved in the gas turbine cycle but even there the pressure might not be important as far as the effect on the production of oxides of nitrogen is concerned.

I think the approach to an equilibrium condition is in the high temperatures of the furnace but the thing on which we have very little information is what happens to this gas as we cool it down and pass it through the furnace and what, for instance, would be the effect, the catalytic effect or otherwise, of the fly ash content upon this change in temperatures as we cool.

JOHN W. PURSSELL, Jr. They say that exceptions prove the rule. You have indicated that low-sulfur and low-ash coal is not generally available for utilities. But in Boston, where freight is two-thirds of our cost of fuel, we do get low-sulfur or low-ash coal, figuring there is no point in paying the transportation to get it dumped there—about eight-tenths sulfur and 5 percent or 6 percent ash.

Industrial Sources of Air Pollution (4)—Metallurgical

Thomas C. Wurts
Director, Allegheny County Bureau of Smoke Control
Pittsburgh, Pa.

The title for my remarks today is a little too all-encompassing. I will limit what I have to say to the ferrous industries and to our concentrated experience on this subject over the past 9 years in Allegheny County. As you all know, nonferrous industries, such as copper, zinc, aluminum, etc., have definite air-pollution problems distinctly different from what I am planning to tell you.

Ferromanganese Furnaces

Two furnaces produce approximately 670 tons per day of ferromanganese. In doing this, they produce an effluent which, if unchecked, is without question the most prolific of any of the metallurgical processes. By means of electrostatic precipitators, over 100 tons of particulate matter, weighing only 12 lb. per cu. ft., is recovered from the effluent. This material is then treated by a roasting process and produces a product weighing only 30 lb. per cu. ft.—still too light for successful open storage, with a net result that it must be put through another process of briquetting before it is sent to the dump. There is no economical recovery in the resulting material and the only compensation from this very expensive installation is the ability to use the cleaned effluent gases under the boilerhouse furnaces and this has only a Btu value of 120.

Aviators have told me that the predecessor furnaces without effluent control produced a cloud of smoke which under certain atmospheric conditions they could follow in for 300 miles

Open Hearth Furnaces

Eleven 300-ton furnaces are now in process of being equipped with electrostatic precipitators. These furnaces have a daily capacity of 7,350 tons of steel.

Open hearth stacks are looked upon by the general public as terrible polluters of the atmosphere. The electrostatic precipitators will collect better than 90 percent of the particulate in the effluent but even so, it is anticipated that these 11 furnaces will only produce collectible particulate of 30 tons per day. Compare this with the recovery in the gas of the ferromanganese furnace just mentioned. This is almost entirely iron oxide and, after sintering, will be recharged into the blast furnaces. The effluent gases have no byproduct value.

In addition to this installation, a venturi-type wet scrubber is being installed on one furnace.

These two installations will result in very excellent comparative data as to the economics of the two types of particulate collection. It is most gratifying that this is being done on a full-scale basis rather than on a pilot-plant basis as I think everyone will agree that pilot-plant experiments are sometimes misleading.

Blast Furnaces

The gases produced are all cleaned to comfortably meet the 0.40 lb. per 1,000 lb. of gases required by our ordinance. There is of course recoverable gas of approximately 90 Btu heat value. It can be said that from a gas standpoint blast furnaces are not violators of the ordinance.

These furnaces have a capacity of 21,000 tons of pig iron per day and the recovery of flue dust from the gases is approximately 1,000 tons per day or better than a 95 percent recovery. This flue dust is sintered and recharged.

There is one very vexing problem in connection with blast furnace operation known as "slips." Operating people attribute these "slips" to a variety of causes. The furnace or bank of furnaces may go along for a number of months with negligible instances of "slips" and suddenly an epidemic will start, apparently without reason and without know-how on the part of the operating people to prevent them.

Bear in mind that a "slip" is an economic loss inasmuch as the furnace production is materially disturbed by such operation.

Auxiliary Furnaces (Soaking Pits, Heating and Reheating Furnaces, etc.)

These can be prolific producers of dense black smoke. Careful operation has proven that such dense smoke can be almost entirely eliminated with the careful control of the fuel-air ratio.

Bessemer Converters

Fortunately this type of steel producer is rapidly disappearing. Their proper control so far is admittedly an economical impossibility. Fortunately we only have three such furnaces in our area and they operate only two at a time. We are looking forward to attrition to take care of this problem.

Electric Furnaces

For the past 5 years we have had a research committee, authorized under the terms of our ordinance, that has been investigating proper means for the control of the effluent from these furnaces. We are fortunate in having on this committee not only electric furnace operators but also the design engineers of three electric furnace manufacturers. We are very much in hopes that a modification of design, coupled with practical furnace operation, will result in an effective collection and suppression of effluent gases.

The committee has undertaken a full-scale experimental installation on an electric furnace with a view to determining whether a full collection and suppression of effluent gases would have any effect upon the final product from the furnace. This equipment went into operation last July and to date the results are highly encouraging.

Coke Ovens

Improvements in modern design have resulted from the use of self-sealing doors, hoods over the charging machine, and a better maintenance of oven walls. The problem of the emissions at the time of pushing and of quenching the coke is still a matter to be improved.

There is probably no chemical plant where the byproduct gases are reduced to useful products that does not produce a certain amount of odor. However, repeated investigations by mobile testing equipment close to the source of these unpleasant odors have never shown any harmful pollution. As a matter of fact, in the majority of instances nothing was produced which would even show a flicker on the instruments, thus proving the extreme sensitivity of our olfactory nerves.

Future Developments

Some of the problems still to be solved are:

1. The control of effluent from electric furnaces.
2. Pushing and quenching of coke.
3. Blast furnace slips.
4. Cheaper means of controlling open hearth effluents.

Summary

A very careful analysis of all of the various pollutants resulting from steel mill operations I think conclusively proves that no health hazards result even under severe inversion conditions.

DISCUSSION

A. L. Kiewit. Do you have any of the latest types of furnaces which involve somewhat the Bessemer process but have a bubbling of oxygen through the bath of steel?

Mr. Wurts. We do not, in our territory, have any experience on those. There are a few of them being used. I think the production of the effluent is vastly increased and there is also the problem of lancing the bath in the open hearth furnace with oxygen, which is not being done as yet. But the equipment that is being installed in connection with these 11 furnaces I spoke about intends to take cognizance of the possibility of lancing the bath. As I understand, lancing the bath vastly decreases the life of the lining of the furnace. It's a question of whether it's an economic proposition.

Professor Chanlett. Yesterday afternoon, Mr. Howell, representing the steel industries, said that there will shortly be data published on relationships between pathology, health effects, and effluents from steel industries. In making your statement that no health hazards are presently recognized, did you mean that in terms of a specific disease, a specific pathology?

Mr. Wurts. I meant that in connection with our own local environment and I might qualify that. We have a very peculiar topography that one might think would not be conducive to good air drainage, but even with the conditions we get, we do get air drainage out of our valleys, so that even with inversion conditions from the steel industry itself, we have never come up with a health hazard. One of our famous health hazards that has been mentioned already in this meeting came from the zinc industry and not steel and that zinc industry has been shut down.

Industrial Sources of Air Pollution (5)—Chemical

Dr. E. M. Adams
Associate Director, Biochemical Research Department
Dow Chemical Co., Midland, Mich.

A. Industrial Coverage

1. Not alone operations for manufacturing of chemicals but also those that use chemicals.

2. Under chemicals are included many items normally given more specific designation, i.e., dyes, paints and coatings, fats and vegetable oils, rubber, leather, glues, pharmaceuticals, pesticides, products of fermentations, clay products, cement, and many others. (In effect, the

coverage is virtually all other industry not specifically designated in this program, i.e., petroleum processing, power generation, and metallurgical operations.)

B. Available Data and Present Understanding

1. Sources of information:
   a. Popular publications (newspapers).
   b. Special reports of surveys, etc.
   c. Air cleaning equipment manufacturer.
   d. Technical literature.
      (1) Specific publications on air pollution matters.
      (2) General chemical and engineering literature.
      (3) Meteorological studies.

2. Present understanding of chemical operations as a source of contaminants.

a. Virtually all chemical operations can be, or are, sources of some contaminants, i.e., there is a waste material or there is an operation which permits the escape of substances into the air.

b. Chemical operations are extremely diverse in nature, size, and location, although appreciable standardization is developing: the substances discharged are extremely diverse in chemical composition (there are literally thousands of different substances encountered in chemical operations in this country and in Europe).

c. In specific localities and circumstances, certain chemical operations have been the cause of air-pollution problems (SO_2, HF, HCl, solvents, varnish fumes, "odors," Cl_2, Br_2 Herbicides).

d. There is very little *published* information on quantities of substances and rates of emissions. One can infer that such information has been obtained in a goodly number of instances.

C. Answers to Specific Questions

1. What are the types and quantities of pollutants from the sources in question?

Types are extremely diverse chemically: their enumeration will amount to an enumeration of all types of chemical substances.

No useful summation of quantities can be made although it is apparent that concentrations and rates of emissions have been determined where there has been reason to do so.

2. Is this information important? Why?

Both qualitative and quantitative information is necessary in order to accurately evaluate the significance of emissions and to contrive control measures.

3. What is the relative significance of the individual pollutants in relation to the overall air-pollution problem?

Relative significance of contaminants from all types of sources depends upon local circumstances. Grossly, most of the "chemical" sources seem to have been unimportant. Among various localities, they may have varying importance up to and including primary.

4. Are the types and quantities of emissions likely to vary significantly in the future? How? Why?

We can expect new types of substances simply because new processes and new products are being developed. In specific localities, the location of new industries may introduce new contaminants for the area.

Quantities of contaminants in total will tend to increase wherever new sources are introduced.

Whether or not an increase actually occurs will depend on the extent of control and on the specific nature of the chemical operations.

5. Are present methods and knowledge adequate in this field? If not, what still needs to be known?

At present, we have sampling and analytical methods together with understanding of engineering matters which enable one to determine types and rates of emission—probably in every instance. The amount of labor required is such that simpler and more rapid methods are needed. Of particular value are methods using automated sampling and analyzing.

Improved process knowledge as regards control methods and recovery methods can contribute more than outside sampling in many cases. There are many examples where a sharp engineer has cut atmospheric losses and improved his process at the same time. A complete material balance on a process should define environmental losses.

From the viewpoint of local areas, we certainly need a better understanding and better procedures for evaluating the significance of specific contaminants on an absolute basis.

6. How is improved knowledge in this field to be obtained? By whom? How soon?

This question must be answered in terms of those qualified and able (in a position) to do specific tasks. There is a place, if not a need, for work by industrial and academic groups and in the various levels of government.

DISCUSSION

Dr. H. F. Johnstone. Our real object in all air pollution work is to prevent disease and damage to the public in our communities. We know there have been serious disasters in this country and abroad, in the last 50 years at least 9 of them. We know that deaths have been numbered in hundreds and thousands. We know pretty well what has caused these disasters. Let's be sure at all times we know the possibility of this happening again in the United States. I am speaking specifically of disaster caused by sulfur dioxide and its oxidation products, which exist because other substances beside sulfur dioxide are in the air at the time of certain meteorological conditions which cause smog.

Within the last few months we have shown that sulfur dioxide in the air with low concentration—and now I am speaking of low parts per million—is converted within 2 or 3 minutes after a fog falls to sulfuric acid droppage. This, combined with the very important results that have been demonstrated, within the last month and within the last year, at Harvard University, creates a serious toxic condition.

It's the responsibility of the municipal control authorities as well as of industry to prevent such a situation. In several localities in this country, the conditions are set for disaster.

Dr. Kamp. Dr. Johnstone didn't have to remind me because that's what I want to talk about this afternoon. That is a real potential at this time in Louisville. We have a reducing steam type of smog or true smog wherein we have sulfur dioxide and fog. That is the reducing steam and Dr. Johnstone apparently feels that, in the presence of an aerosol, even small amounts of sulfur dioxide will be rapidly oxidized in this steam to sulfuric acid.

There is no need to point out the corrosive and irritating properties of this sulfuric acid aerosol, particularly as it remains in contact with the lung tissue for a relatively long time. The potentialities of this type of damage or disaster, given the right conditions, are always there and it's in connection with implementing the very fine study that has been done in Louisville that I'd like to talk this afternoon.

Mr. Penfield. I always found it was an awful job to get SO_2 to go into SO_3.

Dr. Johnstone. Come around and I'll demonstrate within 30 seconds. It's not much of a job.

Mr. Penfield. The gases that leave the coke boxes in the old, conventional batch fuel will be saturated with water vapor when they leave the coke boxes. They go on into the drying steam and the coke box is considered a very good cleaner-outer. I don't deny that it happens, but I wonder if you have any figures to show what percentage of the SO_2 is converted into SO_3?

Dr. Johnstone. Yes. Within two minutes, over 1 percent but in another twenty minutes it would be, oh, 20 percent or 30 percent.

Dr. Kamp. The sulfuric acid was not determined in Louisville City. Apparently it was felt to be technically too difficult but it has been pointed out that it is not too difficult a procedure and I think this will now be a part of all community surveys. Unfortunately, we don't have an SO_3 determination in our study.

Dr. Johnstone. In view of that last statement from Dr. Kamp, it has been demonstrated that damage to plants by sulfuric acid, not SO_2, has occurred. This concentration is high enough to cause a disaster such as occurred at Denora.

Transportation Sources of Air Pollution (I)—Comparison With Other Sources in Los Angeles

Dr. Leslie A. Chambers
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Few sources of air pollution have been under such close scrutiny in recent years as the automobile and other petroleum fueled vehicles.

This attention is well deserved on the basis of the firmly established major role of vehicular exhausts in the production of smog in Los Angeles, and the inevitable inference that automobile exhausts are contributing heavily to air pollution in other metropolitan areas. Because of large differences in air movement, topography, amount of sunshine, and other climatic influences from one city to another it is not possible to conclude that equivalent amounts of pollutant losses will produce equivalent effects. Nevertheless, it is possible to define in rather simple terms the amounts of materials being made airborne by these transport sources.

All types of vehicles, except those driven by electric power, contribute their proportionate share of emissions, but in most localities the enormous preponderance of gasoline driven machines makes the relatively small contribution of diesel, gas, and coal propelled units quite insignificant, except in the immediate vicinity of their exhaust vents. Therefore, while the problems of diesel engines and locomotives should not be overlooked in the discussions to follow, I will confine my brief remarks at this time to gasoline powered automobiles, trucks, and buses.

In Los Angeles County every effort has been made to determine just how much of a variety of air pollutants come from the operation of automobile engines. With about 2,750,000 cars and trucks registered and a daily consumption of gasoline in excess of 5,500,000 gallons per average day, and in the face of the established fact that the exhaust products from this diffuse source are principally responsible for the eye-irritating, oxidizing smog which occurs more than 100 days of each year, it has been necessary to assess the problem quantitatively and qualitatively. While the cooperative studies conducted by the District, the combined automobile manufacturers, the Bureau of Mines, and other agencies have raised more questions about possible control techniques than have been answered, they have left no doubt about the magnitude of the automobile as a primary source of air pollution.

On the average, the use of 1,000 gallons of gasoline in automotive engines releases to the air:

Carbon monoxide	3,200 pounds.
Organic vapors	200–400 pounds.
Oxides of nitrogen	25–75 pounds.
Aldehydes	18 pounds.
Sulfur compounds	17 pounds.
Organic acids	2 pounds.
Ammonia	2 pounds.
Solids (zinc, lead, other metallic oxides & carbon)	0.3 pound.

It should be remembered that the products from individual cars vary substantially in both directions from the listed values, depending on a host of engine, fuel, and operating variables. But for purposes of determining the amount of pollution being delivered to a metropolitan air supply, the figures have a first order of reasonableness.

They mean, approximately, that every thousand operating automobiles in a community emits daily:

Carbon monoxide	3.2 tons.
Organic vapors (hydrocarbons)	0.2–0.4 ton.
Oxides of nitrogen	0.05–0.15 ton.
Aldehydes	36 pounds.
Sulfur compounds (SO_2)	34 pounds.
Organic acids	4 pounds.
Ammonia	4 pounds.
Solids (Pb, C, etc.)	0.6 pound.

Some of these figures are impressive but their significance is not solely determined by weight. If the air being polluted is moved by winds sufficiently strong to ensure an adequate dilution of the waste products, these quantities may be insufficient to bring the overall air concentration to an objectionable level. It is the concentration actually produced in the mass of air we breathe—not the absolute amount turned loose—that is objectionable or toxic.

Therefore, it is not possible to translate tonnage data, from one local situation to another, in terms of air polluting effect, without considering the dilution factor. How rapidly is new air brought in? How frequently is the air supply stagnated? How often may the same air mass pass over the polluting area? Over what distance is a given air mass subjected to added pollution? Meteorology, topography, and aerial distribution of polluting sources must all be considered.

Up to this point we have considered only quantities. In the Los Angeles area, and perhaps elsewhere, the relative capabilities of the several exhaust substances for reaction to form new products must also be considered. It has been established for several years that some organic compounds react photochemically more rapidly than others to result in ozone, oxidation products such as aldehydes, and a variety of transient and stable secondary products. Quite recently methods based on infrared absorption and gas chromatography have resulted in some progress toward determination of the relative participation of various organic molecules in the reactions of "smog" formation.

Discussion of the reaction rate differences and their implication for exhaust control would take us far afield from the assigned task of this Symposium. On one point there seems to be general agreement. Certain unsaturated organic compounds appear to play a much larger role in the production of various secondary reaction products, e.g., eye irritants, than do others. It is evident that the possibilities of selective removal or elimination of these fast reactors will not be overlooked in the future exploration of methods for exhaust pollution control.

In addition to what comes from the exhaust line, an automobile loses substantial quantities of gasoline vapors from fuel tank and carburetor vents, especially during hot weather. The loss from both sources is minimal at air temperatures below about 80° F. but at temperatures of 95°–100° F. the carburetor evaporation losses from Los Angeles driving approximate 40 tons per hour, a rate of loss which is roughly equivalent to the hydrocarbon losses from the exhaust system. Tank evaporation contributes additional but lesser quantities. Unfortunately the periods of such elevated temperature often coincide with periods of most intense smog. The damaging effect of these evaporative losses is probably offset to a considerable degree by the fact that the vapors contain less unsaturated hydrocarbons than the fuel being used.

The automobile engine is clearly a major contributor of oxides of nitrogen. Since these are an essential ingredient of the smog-forming reactions they require close attention. Indeed some authorities maintain that it will be necessary to reduce exhaust emissions of oxides of nitrogen, *as well as of hydrocarbons*, before any full solution of the Los Angeles smog problem is reached.

The large amounts of carbon monoxide produced by automobile engines is both a benefit and a potential danger. In concentrations higher than about 150 parts per million of air, it is a health hazard. But at any concentration it affords a fairly firm basis for determining, from measurements of its atmospheric occurrence, the approximate amounts and degree of dilution of automobile exhausts. This is possible because the engine exhaust is, overwhelmingly, the principal source of carbon monoxide, and because CO does not appear to be used up by reactions in the atmosphere. It is therefore useful as an index of the distribution and degree of dilution of other exhaust constituents.

In summary: Exhausts from automotive vehicles—chiefly gasoline propelled—contribute pollutants to the atmosphere in very large quantities. The significance of the quantities, in any particular geographical locality, is influenced by the availability of diluting air, and by meteorological factors which govern the formation of reaction products from the primary pollutants. Any metropolitan area having its transportation based on petroleum powered vehicles receives primary exhaust pollutants in the same degree per thousand operating units as any other. In some the resultant concentrations may be tolerable; in Los Angeles these exhausts are basically responsible for a serious community problem which inevitably will increase with growth in automobile population until a means for substantially eliminating some constituents of the exhaust is put to effective use.

Transportation Sources of Air Pollution (2)—The Automobile

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Upon reviewing Mr. Hanauer's questions, which were to be used as the basis for our discussions, the temptation to take the fifth amendment became almost irresistible. A very substantial amount of work has been done by our industry and by others on the subject of analytical instruments for measuring exhaust, on variables which affect exhaust constituents and concentrations, and on air pollution effects of different components of the exhaust. A good many answers have been obtained, but these have raised additional new problems. The questions of establishing what and how much the automobile contributes to the atmosphere has revealed itself to be a most complex one, and when the additional question of the significance of this contribution is raised, any careful investigator will find it most difficult to be precise in his answers.

Let me illustrate by attempting to answer the very incisive questions selected by the chair.

Question 1, "*What are the types and quantities of pollutants from the sources in question?*"

Well, let me start the easy way. The tailpipe of the automobile emits a substantial variety of particulates, among which are salts of barium, iron, calcium, lead, zinc, potassium, and lithium. These salts may be phosphates, sulfates, bromides, chlorides, nitrates, and possibly others. Maximum estimates for the total of these materials are of the order of 0.007 percent by weight of exhaust.

Compared to other emissions which will be discussed this total quantity is insignificant. Since some of these particles are in the light scattering size range, and several are toxic at some concentration, there may be some desire to discuss these particulates further. However, the evidence indicates to me no substantial air pollution effect from this class of emission, so I will pass on to the next constituent. You may have noted that I did not include carbon in my discussion of particulates. The main reason was that the condition of the vehicle is the big factor in carbon formation and the statistical evidence available on the condition of the average car as it might affect carbon formation is not good enough to hazard an estimate of emission.

Moving from the particulates to the gaseous components of significance in the air-pollution problem, we find three of particular importance. These are carbon monoxide, oxides of nitrogen, and organics.

Carbon monoxide has been studied for many years because it is toxic and because it is an excellent index of combustion efficiency. Concentrations in the tailpipe and in the atmosphere have been evaluated frequently. The evidence shows that we have steadily decreased the average concentration of this constituent. Single car values will vary widely with car maintenance and operating conditions.

A field survey conducted approximately 2 years ago on several hundred cars gave information which would indicate that carbon monoxide is about 3.2 percent by weight of the total exhaust during city driving. A recent survey on over 200 cars shows this value to be about 2.0 percent. Data on hundreds of factory-tuned cars give about half of this amount. As will be detailed in the discussion of organics, a tonnage figure for a car population is extremely difficult to establish where both driving habits and vehicle conditions affect the ultimate value. The accuracy of the estimate depends on the size of the sample and the variables of measurement.

Oxides of nitrogen obtained on the same survey indicated that approximately 0.17 percent by weight of the exhaust can be expected in terms of oxides of nitrogen. A previous survey showed a slightly lower figure. Here again, type of operation plays a major part. The problem of estimating this constituent group is further complicated by the rapid change of the oxides ratio and by the lack of continuous portable instrumentation for measuring the various oxides.

Probably the greatest number of questions exist in the area of measurement of the organic constituents of the exhaust. The uncertainty is in the instrumentation, the high degree of variation among vehicles, the tremendous effect of automobile operating cycles, and perhaps, other variables not yet thoroughly understood. For instance, in preparing this particular presentation I looked at 19 sets of values obtained by various people and representing nearly 1,000 different vehicles. An average idle condition for factory-tuned cars was about 0.11 percent by weight of the exhaust. The *average* idle readings for other groups of cars were over four times this reading. All values used were obtained with essentially the same type of instrumentation, namely, the hexane detector in a nondispersive infrared analyzer. If I were to include values obtained with the mass spectrometer and with the benzene-acetylene-ethylene sensitized detector I would be able to double this range. Similar spreads have been recorded for acceleration, cruise, and deceleration. Furthermore, there are at least fivefold average variations in concentration among the various cycles.

Thus far we have been talking only of concentration, but in order to arrive at a total tonnage figure, concentration must be multiplied by volume. The volume of air flow will show tenfold *average* variations in city driving. Thus it becomes evident that in order to arrive at an accurate figure for total contribution of organics to the atmosphere a large number of cars, possibly in the thousands, must be run, and several independent variables must be accurately measured. In view of the complexity of the measurements and the general state of knowledge in this area I believe it is fair to state that any figure for total organics can only be a rough estimate. A range of 0.2 percent to 0.4 percent by weight of the total exhaust appears reasonable based on present data.

We do not tell the entire story of the organic contributions from the tailpipe by saying that they are of this order. Within the area of total organics we find several hundred or possibly several thousand organic components which, according to the latest findings, have varying effects on such air-pollution factors as eye irritation, toxicity, plant damage, visibility, and soiling. What are these components? Well, you could take your favorite handbook, pick out a mass of components within the C-2 and C-10 range and you would probably be able to establish as good a table as could be given at the present time. Each next set of individual component analyses of the exhaust reported appears to add some new components. These are apparently affected by type of fuel, engine operation, and sometimes, I suspect, by method of analysis.

With this framework, let us examine question 2, "*Is this information important? Why?*"

The answer obviously is in the affirmative. Different amounts, types, and ratios of constituents produce widely different effects. Again, time will permit me to cite only a few examples. Work on the atmospheric reactions in the Los Angeles area has indicated that the ratio of oxides of nitrogen to organics is extremely important. It has indicated that the percentage of olefins will have a significant effect on the eye-irritating properties of radiated exhaust mixture. Ozone formation appears to be related to the total organics. The presence of aldehydes and ketones will have a distinct effect on eye irritation. Some nitro organics have extremely high lachrymating properties and enough anomalies in the phytotoxic properties of irradiated exhaust exist to lead me to the conclusion that specific organics may have widely different effects on plants.

Perhaps from our industry point of view, the most important reason for knowing exactly what goes into the atmosphere from the exhaust and how much of each type of material is exhausted is so that we can apply remedies. Whether these remedies be in terms of a device or in terms of better maintenance, or in terms of engine modification, or in terms of fuel modification, the knowledge of how much there is to reduce and what percentage of reduction is necessary is important. The ideal device or engine modification or fuel change is one which would reduce all organics to the vanishing point. If this were accomplished, specific data on types and amounts would be unnecessary. Practically, nothing of this nature appears probable.

The third question, "*What is the relative significance of the individual pollutants in relation to the overall air-pollution problem?*" is really an extension of the second one, and here the answers are even less definite.

A good working limit for carbon monoxide has been established. The same is not true of oxides of nitrogen, and is certainly not true of individual organics, or indeed, total organics. There is some question in my mind whether in the absence of the conditions that promote a photochemical reaction in the atmosphere, namely, low air mobility, high light intensity, and severe inversions, organics of the order emitted by the exhaust have any demonstrable significance in the total air pollution problem. Long range health studies may give a useful answer in this area.

Question 4, "*Are the types and quantities of emissions likely to vary significantly in the future? How? Why?*", would have to be answered by looking at the past.

We have lowered carbon monoxide and smoke from vehicles very significantly over the years. I believe that had we had measurements on organics the same story would have been recorded. Better combustion reduces the unburned and partially burned organics. The history of the automobile industry in achieving better combustion has been a very successful one. This trend can be expected to continue. In addition, better maintenance and afterburners and, perhaps, fuel modifications can be used to accelerate this trend where necessary. It is certainly to be expected, therefore, that the concentrations of total organics and carbon monoxide will be reduced in the future.

Question 5, "*Are present methods and knowledge adequate in the field? If not, what still needs to be known?*"

What still needs to be known can be answered in considerable detail, just to cite a few things, instrumentation needs to be improved very substantially. Knowledge of the individual components requires expansion. The maintenance effects which tend to increase emissions needs to be clarified. More knowledge needs to be obtained as to precisely how cars operate in the field. The effect of fuel needs to be investigated further, and most certainly the atmospheric reactions require substantially greater study in order to establish relative importance of the various exhaust components in which constituents are undesirable.

The 6th and last question, "*How is improved knowledge in this field to be obtained? By whom? How soon?*", leaves me in the field of speculation.

Many of you already know of the very substantial program being conducted by the automobile industry to improve knowledge in the areas outlined in the questions above. There are many other facilities at work, including the U.S. Public Health Service; the Los Angeles Air Pollution Control District; the Coordinating Research Council, American Petroleum Institute; the Air Pollution Foundation; the Bureau of Mines; and the Air Pollution Control Association; just to mention a few. These and many other agencies will develop information as rapidly as technology will permit. How soon will adequate information in these fields be available? I don't know. The field is one where original research and invention are still playing a prominent part. Neither of these two can be programmed. The work is proceeding energetically, and new knowledge is constantly being obtained. With continued hard work and perhaps a little good luck, some answers should begin to appear soon.

Transportation Sources of Air Pollution (3)—Petroleum

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American Petroleum Institute

Transportation sources of air pollution include aircraft, boats and ships, trains, trucks, and buses, as well as automobiles. Aircraft and ships operate primarily in unpopulated areas, and their contribution to urban air pollution is relatively insignificant. Trains, trucks, and buses are, in a great many instances, diesel propelled, and the average citizen is, from time to time, aware of pollution in the form of odors and smoke. However, diesel exhaust is only a very small fraction of the total air pollution from transportation, and because it is a relatively minor source, little work has been done to control it. Diesel engines properly operated and properly maintained produce a minimum of smoke and odors. Research organizations and individuals studying air-pollution problems are aware of the contribution to air pollution from diesel exhaust, and research in this field is contemplated or is under way in several instances.

Since the major source of pollution from transportation is the exhaust from the gasoline-powered automobile, my remarks will be confined to a study of this problem.

If a gasoline engine could be operated to produce complete combustion, the exhaust products would be carbon dioxide, water, and oxides of nitrogen. Unfortunately the combustion process is not complete in any practical engine, and the resulting exhaust contains hydrocarbons, oxygenated products, carbon monoxide, soot, and smoke, as well as carbon dioxide, water, and oxides of nitrogen.

Carbon monoxide is a toxic constituent of exhaust and as such may in certain instances be a health hazard. Oxygenated products produce annoying odors, and smoke from exhausts contributes to visibility reduction and general soiling of the surroundings. The hydrocarbons and the oxides of nitrogen react in the presence of air and sunlight to produce the manifestations known in Los Angeles as "smog," characterized by eye irritation, the formation of areosols, damage to vegetation, and increased concentration of oxidant, principally ozone, in the atmosphere. Automobile exhaust contains something of the order of 300 to 5,000 parts per million hydrocarbons, depending upon the driving cycle. In Los Angeles County, about 2¾ million cars consume an estimated 6 million gallons of gasoline daily, so it is readily apparent that in this area at least, automobile exhaust is a primary source of air pollution. It is estimated that hydrocarbon emissions from automobiles in Los Angeles County amount to about 1,000 tons per day. This is ten times the hydrocarbon emission from all the refineries operating in the area.

The petroleum industry supplies the fuel used by the automobile, and thus has a sincere interest in the solution to the problem of pollution from automobile exhaust. The stated objective of the Smoke and Fumes Committee of the American Petroleum Institute is "to determine the causes and methods of control of objectionable atmospheric pollution resulting from the production, manufacture, transportation, sale and *use* of petroleum and its products."

Several laboratories have repeatedly demonstrated that ozone, eye-irritating materials, and aerosols are formed when hydrocarbons and oxides of nitrogen in concentrations in the parts-per-million range are mixed with air and irradiated with artificial sunlight. The ability to produce and control this reaction in the laboratory has made possible a study of many of the variables suspected to influence "smog" formation.

Motor gasoline is a complex mixture of hydrocarbons with a wide range of chemical and physical properties. To insure that automobiles will respond satisfactorily under all conditions of operation, the fuel must be properly balanced. The driver expects his car to start easily, warm up fast, and respond instantly when he steps on the accelerator. In addition, he demands good mileage and a gasoline free from knock. To meet all these requirements, refiners blend gasoline to take into account the geographical location and the season of the year as well as the characteristics of the motor car itself.

The knowledge that trace quantities of hydrocarbons present in automobile exhaust play a critical role in the smog-forming reactions has led to the suggestion that some modification in fuel composition might produce an exhaust with less air pollution potential than motor fuels presently in use. Changes in fuel composition could not be expected to reduce the *total* amount of hydrocarbon present in automobile exhaust: the only possibility would be to change the *type* of hydrocarbons emitted.

In an effort to provide factual information on the effect of fuel composition on air pollution manifestations from automobile exhaust, the Air Pollution Foundation and the Smoke and Fumes Committee of the American Petroleum Institute entered into a cooperative research program during the period June 1957 to June 1958 to investigate this problem thoroughly. Facilities developed at Stanford

Research Institute for the irradiation and study of diluted auto exhaust were provided under APF sponsorship. The Franklin Institute Mobile Air Pollution Laboratory, housing long-path infrared equipment, and the facilities of the University of California at Riverside Air Pollution Research Group were brought into the problem under the sponsorship of the API.

The study was designed primarily to study the manifestations of air pollution such as eye irritation, aerosol formation, ozone formation, plant damage, and various chemical factors from the exhausts from test fuels. It was not the purpose of this project to establish the chemical nature or the manner of formation of the products of the photochemical reactions.

The equipment used included a test automobile mounted on a chassis dynamometer and equipped with suitable automatic controls to produce the various phases of automobile operation. The exhaust produced was collected, diluted with purified air, and pumped into a 520-cubic foot chamber where artificial light sources were used to simulate sunlight irradiation. Chemical sampling devices and test instruments were provided to monitor the exhaust mixture, and a panel of male college students was used to measure eye irritation. Four test fuels were used in this study. Three fuels representing extremes in hydrocarbon composition were compared with a blend of commercial gasolines sold in Los Angeles. Four automobiles were selected, representing typical cars found on the road today. The cars were not new, but had indicated mileages from 22,000 to 60,000 miles. These cars were tuned and equipped with new points and plugs before the tests were carried out, but were not otherwise serviced.

In studying automobile exhaust, the operating cycle chosen is an important variable. Under idling and decelerating conditions, the exhaust is high in hydrocarbon content, while under cruising and accelerating conditions, hydrocarbon emission is less and oxides of nitrogen emission increases. Earlier work by the Air Pollution Foundation has shown that eye irritation depends to a large extent upon the concentration of hydrocarbons and the ratio of hydrocarbons to oxides of nitrogen in the exhaust mixture. Thus, it is apparent that a choice of operating cycles is important in a study of this kind. To match the actual situation as closely as possible, the driving cycle used followed a traffic pattern survey conducted by the Automobile Manufacturers Association in Los Angeles.

The results of these experiments have shown that substantial eye irritation was developed from the irradiated exhaust from each of the four fuels tested. The exhaust from the highly olefinic fuel reacted more rapidly under irradiation than exhaust from the other fuels tested. The rate of ozone formation from irradiated exhaust varied with fuel composition, but the quantity of ozone produced was independent of fuel composition. During a number of experiments, plants were exposed to irradiated exhaust with the intention of comparing damage produced by the different samples. None of the exhausts produced more than slight traces of the oxidant-type plant damage characteristic of "smog." Individual automobiles vary markedly in the air polluting potential of their exhausts, and differences in automobiles have as great an effect on the manifestations of air pollution from exhaust as do differences in fuel composition.

A study of a somewhat similar nature is in progress at the Bureau of Mines Petroleum Experiment Station in Bartlesville, Okla. Here the primary emphasis has been on the analysis of exhaust gases to determine the hydrocarbon composition. As a part of this study, many different fuel types have been used in a test engine and the exhaust products analyzed. Results from this study have shown that olefin contents of exhaust hydrocarbons tend to increase with increase in engine severity, regardless of the fuel used. In terms of fuel composition, aromatic compounds in a fuel are heavily reflected in the exhaust products, while olefins in fuel are reflected to a lesser degree in exhaust, but are heavily influenced by the driving cycle.

Thus, it is apparent that while changes in fuel composition do have some effect on the hydrocarbon composition of the exhaust, no appreciable effect on air pollution manifestations can be accomplished by changing fuel composition. As long as there are hydrocarbons and oxides of nitrogen emitted from the tailpipes of automobiles, we can expect to have eye-smarting, visibility-reducing "smog" in areas like Los Angeles where traffic density is high and natural ventilation is poor. The only sound approach to the problem seems to be to add to our automobiles a device to convert the exhaust to that ideal condition mentioned earlier where the products of combustion are harmless carbon dioxide and water.

DISCUSSION

Dr. Chambers. It is evident from the material that has been presented in all three papers pertinent to the subject on hand, namely the automobile as a source of pollution, that there has been no collusion among the three authors covering essentially the same ground. We have come up with about the same determination as far as the pollutants contributed by automobiles are concerned.

While this is not strictly related to the automobile as a source of pollution, many of us would have to take the position that the conclusion stated at the end of Mr. Jones' paper, namely that no practical effect can be realized by any change in fuel composition, is not yet proved. We can say this with a reasonable degree of definiteness in view of the fact that the data produced by the foundation referred to by Mr. Jones are now in the form of a report, and I call your attention to the inconsistencies in the various conclusions drawn by the authors of that report.

The problem is not settled. I am not contending that it will be settled favorably. I don't know. But I don't believe that on the basis of present evidence we can conclude any more than that the subject is one which should be studied, although not with the expectation that full composition control can ever effect a complete solution of the hydrocarbon problems. That, I agree, will only come about with the development of some tailpipe device which will essentially burn up the hydrocarbon.

On the other hand, practically, we have to recognize that any such device that is now in sight is potentially so costly that to apply it in a community like Los Angeles, for example, is going to mean an expenditure of a half billion to a billion dollars. In my opinion the public in any locality is going to be much more susceptible to a partial solution if it can be accomplished on a more economical basis.

We've got to recognize some political realities in this situation and if there are possibilities of making life tolerable by a partial control through some means such as fuel control, then we need to explore that to a true conclusion and not to a conclusion announced in advance.

Mr. Marsh. First, as a layman, it is clear to me that we have a very large problem. We all certainly must be interested in it if we are good citizens.

Second, it is a problem in which there is a tremendous need for further knowledge because it is quite evident that it is not possible to be specific on some of the matters on which one would hope that we could eventually be more specific and on which there appear to be important differences of view. One is changing the fuel itself. This is something that shouldn't be tossed aside at this time if the problem is as severe as it appears to be and if the part which the motor vehicle plays is as important as appears to be indicated. From the point of view of a user of automobiles, I think that the average chap who is the owner of a motor vehicle is a bright, reasonable fellow who wants to do what he ought to do but doesn't want to be gypped in the process. He doesn't want to be asked to do something or put something on his car which somebody assumes will do something which has not been proved that it will do, and which somebody all of a sudden gets all excited about and gets some legislative group to adopt a law on, when the matter has not been adequately proved by impartial research. Frankly, our organization for one, the American Automobile Association, will fight that very hard if it is attempted. I think you would expect that we would, and we shall.

On the other hand, I think quite the reverse will be true if there is demonstrated to be a need for something and this has been worked to a point where the facts are known and what can be accomplished is known and we can be shown that it is important to our people and their health and the condition of cities, and that it has been brought to a stage of reasonable cost. This last, I know, takes time. When you get it, you will find there will be support for that, whatever it may be.

There is a very great danger on many of these problems which arise, with somebody all of a sudden deciding that this is something which we've got to have a law on right away. Or somebody gets an idea and they become perhaps a little "hipped" on that and fail to take into account some of the practical aspects of it. In their own enthusiasm they lose track of those aspects and sometimes they sell their idea and something is foisted on the public, or attempted to be foisted on the public, something for which the public is not ready and which the public should not be asked to take because the idea is not proven and demonstrated. On the other hand, the person driving the car will go along with sensible things, once they have been demonstrated.

Now, I would like to know a little bit more about these afterburners, about what the possibilities are in changes in muffler design.

I also hope that the area of exploration of the fuel itself will be left wide open. If we have a problem so severe as has been indicated here, this should not be closed at all.

I hope, since the diesel engine is going to become more prevalent that this will not remain a minor problem. It should be given maximum attention as it is a very real problem; at least, it seems so when I have the misfortune to drive behind some of the diesel units.

Motor vehicle owners, I think, can be expected to come into this field in a practical way and to do what they can. It has been mentioned here several times that the factor of the condition of the engine is a very important one. Well, if it is, I think this needs to be spelled out a great deal more. We don't know what the factors are that we should give special attention to and if it is as important as some of you believe it is, it is your responsibility to put this into a form that lay people can understand. Then you will begin to get some of the rest of us, who are not specialists in this field, to understand how severe the problem is and to become favorable to the pattern of action which you are going to evolve.

Mr. REHM. My viewpoint expressed here will be that of a control administrator. All of us could not help but be impressed with one thing that was common to all of these presentations and that was the lack of specific information on specific emittants. There is certainly a dearth of this type of information available and we are somewhat at a loss, from a control standpoint, as to where and to what degree we control these various emittants from the various industrial and municipal sources.

Part of the reason for this, I believe, is the lack of instrumentation available to do the job of accurately measuring these various emittants. All of the speakers have expressed this as one of the first needs in their particular areas, to have better instrumentation so that we actually know what is being emitted into the atmosphere. There are, as Dr. Adams pointed out, methods available to us to measure these emissions and to evaluate some of the sources of emission, but the time and the costliness of these particular testing procedures have made it next to impossible, at least from the control standpoint, to put an effective program of measurement into effect.

As an example, I don't suppose that there are more than a half a dozen air-pollution agencies in the country who do source emission testing and this is a far cry from what is needed to actually assess where we are going and what the limitations might be.

I think herein lies an area where our air-pollution control agencies could make a substantial contribution by increasing activities in these fields. Behind all of this is a lack of correlation between emission rates and effects on health of specific emittants or, as we most frequently see them in the midwestern and eastern areas, nuisance effects.

In our particular area, turning to the presentation by Dr. Eliassen, we have done quite a bit of testing work on emittants and while not much of this work has been published as yet, we have done a lot of work, particularly in the field of incineration. Some figures which we use that weren't presented are the emissions from incinerator sources. We have found that in the range of municipal incinerator plants, incinerator plants without benefit of any type collection, will put out in the range of 20 to 25 pounds of particulates. In this case we have dealt as most air-pollution control agencies do with particulate emission. Though we concern ourselves with others as well, our greatest field of activity has been in this particular scope, 20 to 25 pounds per ton of material.

Well controlled municipal incinerator plants might be expected to have put out something in the range of 2 to 3 pounds of particulates per ton of material refuse disposed. When you are talking about the commercial and industrial ranges, you are talking of something over 8 to 10 pounds of particulates per ton in flue-fed incinerators, apartment incineration, 25 to 40 per ton of refuse disposed.

In the field of the powerplant, electric utility, coal fired, we have found that a very good figure from a lot of test work—this represents some three or four hundred individual tests—that a mechanical and electric utility station burning pulverized coal with mechanical collection could be expected to put out about a ton per day per thousand kilowatts of capacity. One embodying control equipment of electrostatic type would be putting out somewhere in the range of eight-tenths tons per day per kilowatt.

With regard to Mr. Wurts' paper and meteorological sources, one particular source that we are concerned with from the control standpoint—mainly because of the fumes of such operations—is the cupola, which he neglected to mention. We have found in this type of operation that 25 or 30 pounds of particulate per ton of iron melted is a fairly good figure for source or emission rate.

The main point I want to stress now is that in order to arrive at these emission rate figures, a lot of time is required. It is a very costly procedure to conduct these source emission tests. As was mentioned, one person will quote another and finally we accept these things as gospel.

There are very few basic emission rate data available today, as all of you have pointed out, and this is primarily for lack of instrumentation, for lack of a type of instrument or test procedure which can be economically run and which will give you reliable data.

Mayor SUOZZI. This session has enlightened me but also discouraged me. It has enlightened me in pointing out the complexity of the overall air-pollution problem and at the same time discouraged me in that I am going to find it very difficult to solve the air-pollution problem in Glen Cove before my term is up. We do have a problem.

Mr. Marsh said that you people are going to have to tell us in laymen's language what the problem is but, as a mayor and a public official to whom the public refers its complaints, I want to know how to solve the problem. Especially in a community where we don't have anyone to pass the buck to, like a control unit or an air pollution research group, we public officials *need* to know how to solve these problems.

I am encouraged by the amount of research that is going on and perhaps in the near future we might be in a position to tell the people who are causing these problems where they can get the information and the knowledge and the technicians to solve them.

Of course one of the most dramatic causes of air pollution as far as the municipality is concerned is the problem of incineration and dump burning.

Because of the problem caused by ineffective or open dump burning, we have concentrated our attention on trying to improve the methods of burning and I wonder whether we should not try to concentrate some of our attention on trying to eliminate or reduce the need for burning. Possibly we should think in terms of encouraging research in the field of converting or making a byproduct of the garbage itself, without any burning. Possibly in this way we might solve a twofold problem, the problem caused by burning and possibly the problem of returning to the soil that which is taken out.

I know there are many methods of composting and fertilization of garbage that have been looked into and tried unsuccessfully but I think perhaps a little more attention might be paid from the air-pollution angle to this kind of solution. It should help to reduce the problem caused by incineration and ineffective burning.

I hope that in the near future we public officials will have the means and the knowledge with which to help industrial citizens and help ourselves in trying to minimize this problem, which is of great concern to all of us.

Mr. ENGDAHL. If I can recall to your mind the total figures that Professor Eliassen gave in his table I, the backyard incinerator was listed to produce 46,800 pounds of effluent per day for each 100,000 population. In comparison, the next column showed 40,000 pounds per day from household incinerators. If Professor Eliasson had as intimate an acquaintance as some of us have had with backyard incinerators and household incinerators, I think he would have known that something is wrong with those figures. You don't need elaborate testing to show you that. A backyard job is a pretty sad affair and Los Angeles did right getting rid of them. Nobody pretended they were going to solve their problem by that but it certainly could not do them any harm. Not only can your common sense tell you that 40,000 is not right for our household incinerators but what's more, at Battelle we now have data which were developed for the American Gas Association on six commercial-residential gas-fired incinerators now in production from which the total emission in these same terms will not be 40,000 pounds per day per 100,000 population, but of the order of 1,000 pounds per day per 100,000 population—one-fortieth of these figures.

We need to get busy and publish those figures. The incinerators, remember, are not laboratory models: they are standard commercial models sent to us by the manufacturers. We helped some of them develop them but a great deal of development effort was done by the manufacturers themselves. We have actually seen chicken feathers and chicken cleanings thrown into one of those units and then seen air-pollution officials walk up to it right after and smell the open stack coming into the room. They said they could hardly believe it, but it is true.

Mr. HEINEN. Diesels were mentioned here rather prominently and I think that something must be explained to the non-Los Angelinos in this audience. Essentially what all three speakers this afternoon were talking about were the organic emissions to the Los Angeles atmosphere and the reason the diesel was ruled out as relatively unimportant is that, in the framework of the Los Angeles problem, I believe the total emission in terms of total organics is 3 percent. When Dr. Chambers implied that the diesels were unimportant he covered himself very carefully by saying, "except at the immediate point of discharge." So you see the framework in which the diesel is unimportant is in terms of total organics.

I want to emphasize once more that this problem of total organics has been shown to be serious in Los Angeles but has not, and I repeat, not, been shown to be serious elsewhere in the Country. This may be partially because of the absence of atmospheric measuring data. But certainly, if irritation is one index of measurement, the problem is in Los Angeles, and to some extent, the other west coast cities where comparatively heavy inversions occur with comparative frequency. The irritating condition resulting from this chemical reaction is not found in any degree of prominence elsewhere in the Country.

This is one of the big mistakes that have been made in this conference, that is, to apply the data from Los Angeles and the significance of certain constituents in the Los Angeles area throughout the United States. I was a little bit amused at the number of times that I heard of Donora, London, and the Meuse Valley. Those disasters have one thing in common, I might add; they were different sources. There was no possibility of photochemical reaction in any case.

Mr. Wurts. Gentlemen, we have made progress! Having cut my eye teeth on steam railroad electrification, and since World War I, on dieselization of transporting apparatus and railroad transportation apparatus, I want to point out one thing that is conspicuous by its absence today, that horrible steam locomotive! Not a word today. We have indeed made progress.

There was a question asked in regard to cupolas. I have omitted cupolas in our papers, because they are insignificant in our area. We have about five and all except one very insignificant cupola is being taken care of by what I call the raindrop method, apparently taken care of quite successfully.

Mr. Orning. This is in reference to the table that was presented to us this morning. When we set up tables of emissions from various sources, of course we'd like to fill in all the blanks and unfortunately there are some places where data is missing. It happens that combustion is one of the oldest arts. Man has been burning fuel since man was able to capture the results of a lightning strike setting off a forest fire or something of that kind and yet it is one of the places where we have an extreme dearth of information. It would appear to me that the emissions given in this table pertain to a hand-fired coal-burning stove. We still do burn coal in such units. Not many housewives who have learned to enjoy the benefits of automatic heating with gas would want to go back to them but we still do burn some in that fashion. Since most of the coal that is burned is not burned in such units, it seems to me to be quite misleading to publish and republish ancient information. I think we ought to reexamine it carefully.

Charles E. Fisher: A question for Mr. Heinen, please.

I am not sure I understood you, but did you state that you were not convinced that if emissions from automotive exhausts were completely eliminated or in large part eliminated, it would eliminate the smog problem in Los Angeles?

Mr. Heinen. No, Mr. Fisher. The question was this: was I convinced that the elimination of the hydrocarbons would eliminate the smog in Los Angeles? I won't even comment on "eliminate": that is an absolute term. I will say that I am certainly convinced that it would reduce it. What I did say, relative to the elimination of organics, was that in areas in the country other than Los Angeles and areas of that general meteorology, I am not convinced that a substantial reduction of the organics would have substantial effect on the pollution problem and I would like to be educated if I am incorrect. However, I will say that data will have to be established elsewhere. There is no doubt in my mind that data have been established from Los Angeles, there has not been any doubt in my mind for over 5 years, and I think there are those in this audience that can attest to that.

I do dwell rather heavily on the subject of establishing just how big a contribution it is, so that when somebody buys those little gems that we hope to produce one of these days, they will know what they are getting for their money. I submit that when there is a two to four times variance in what might possibly be emitted from that particular source, someone like Mayor Suozzi might very well ask as a hard-headed citizen: "You are going to reduce the percent, in some cases 25, in others 75; what does it total overall?"

It is all right to get the automobile industry to work. It was all right to establish the fact that we are major distributors. That was all that was necessary to give us the incentive to go ahead and do something in that area but when we come back and ask somebody to spend a couple of bucks they'll want to know something a little more definite than that this is a big area and we are reducing the amount of pollution. It *is* important in Los Angeles; it is so important that of this million dollars, I would say 900,000 of them were spent on that one particular problem.

Mr. **Hanauer.** My words are going to be completely nontechnical and reflect what I hear every day of the week from the irate housewife, or her husband, who has to wheel the baby carriage along the congested thoroughfare and complains of fumes and smoke and what-have-you from automobiles. From a psychological aspect, the public generally wants something done about auto and diesel fumes. I don't think the housewife will be concerned about the absolute levels as long as she is comfortable walking in the city.

Robin E. Van Meter. As a member of the general public rather than from my professional affiliation, I'd like to ask Mr. Heinen why somebody hasn't brought up the matter of reducing exhaust emissions by reducing engine displacement.

Mr. **Heinen.** That's a very fair question. Just before this session I was listening to a discussion of reducing the engine size. The reason for the big displacements is the manufacturers' interpretation of what the public wants. There is a certain part of the public that apparently wants a lower displacement. This demand has been met, to a large degree, by the foreign manufacturers and to some extent by our American manufacturers.

If the public wants cars at this lower level of engine displacement, the automobile industry will respond. We give them our interpretation of what they want. If they don't want it, we'll change.

A. L. Kiewit. The community I live in has about 50,000 people, strictly residential, occupying about 5½ square miles. Previous to the war, most of the fuel burning in the neighborhood was coal. Since then, there has been quite a bit of conversion to gas burning as every place else. Under the new conditions, wouldn't emissions as shown in that coal table, table I, be reflected in the so-called dust samples or sootfall or dust samples as normally collected? And if so, about how much?

Dr. **Eliassen.** The gross particulates as reported in table I are those caught on a filter. The figures represent filterable material of varying size. It is hard to state what proportion could be designated in particular terms as sootfall. I don't have an answer to your particular question.

Mr. Kiewit. Checking the official records, the dustfall was a little higher than it was previous to the war, but there's so little difference there, you can't say there has been any.

Dr. Eliassen. So many variables enter into this dustfall. They might run out of money in the cleaning. That might affect it more than fuel. It is hard to relate one abstract figure like dustfall to this. I wish we had more data on actual discharge from the coal. We hear the same thing. The only people who are silent are the gas people. We like that. Then they don't like the household incinerators. They have data in their pockets we can't even see. So we give the best statement we can find. If you have others, give them to us.

Mr. Hanauer. By and large, what we are learning in our session today is the areas that need further exploration. Many questions are based on the need for further information, further analysis; and your committee, when it writes the report, can certainly keep this in mind.

Alfred Fletcher. I commented this morning on the ragweed plant as a source of pollen and cause of hay fever. Now I have a few sentences about where it comes from and what might be done about it that I think should be read into the record.

The ragweed plant is found in places where the soil is disturbed—in municipalities, along roadways, alleys, on vacant neglected property, around construction activity such as the development of a housing project, building or widening a street, scraping the sides of streets, following the installation of water lines and sewer lines, and also along State, county, and township roads and in connection with some farm operations.

I think we need to recognize that ragweed pollen is a sickness-producing air pollutant. If we need encouragement to tackle a problem that appears difficult, I would add that we have the knowledge and the tools and would have the citizens' support for tackling this problem. The cost would be reasonable and significant progress is being made in some areas of the United States, at least. I feel that we have brushed off this problem for various reasons too long.

I urge that this air pollutant be included in a far more adequate manner in the U.S. Public Health Service Air Pollution Program.

E. K. Von Brand. On Mr. Heinen's subject, many people believe that where annual inspection is required, in addition to the mechanical inspection of cars, there should be included an exhaust inspection.

Mr. Hanauer. The New York City Department of Air Pollution Control has made this suggestion to the New York State authorities who set up the State inspection and they are very much interested. We may have some results shortly.

Mr. Heinen. Exactly what to inspect for is a very serious question. Fumes and visible emissions, and so on, have come up here for discussion. We in the automobile industry have published a guide as part of our program to help various authorities to know what to consider reasonable or unreasonable.

There are other things that could be analyzed in the exhaust, including these very same organics we are talking about so much. At the present time, establishing the facilities to do a thorough job of exhaust analysis is rather expensive. This is an area that needs considerable work. If this problem is solved, perhaps then we can be a little more specific about some of the figures, bring them down to common terms. I might point out that between speakers we have had a variation in Los Angeles from 200 tons per day to 1,000 tons per day. This will give you some idea of the variation involved. One of these days we will need something more precise. Perhaps an inspection of vehicles will provide it.

Dr. Adams. Several years ago I heard a part of a report on an investigation of the situation in Chicago and one item has remained with me. The report indicated that a quite high percentage, one quarter to a third, of the total mass of particulate matter that was collected in an area by one of these dustfall contrivances, was actually material that was being kicked up from the ground, from the street, the surfaces of the town.

This matter was mentioned briefly this morning but I would like to emphasize that the surfaces of our towns could represent a point of accumulation. You could have emission in no great quantity—fly ash refuse to a very considerable degree—but over a period of years, you could have accumulation on the surfaces with the result that we who are running around on these surfaces are exposed more than we might anticipate. Maybe we ought to think more about our housekeeping.

Prof. Chanlett. I wonder if Dr. Adams would share with us the comments he made to me this morning concerning the value of materials balance in chemical processing operations as a way of estimating emissions sources and the like.

Dr. Adams. To explain at least my understanding of the materials balance, in any process we put in materials, react them, do things chemically, and then take out products, byproducts, and what we call wastes. Materials balance essentially will consist of adding up all the materials that go in and all the materials that you can recover and see how the two figures compare.

In many cases the materials balance on a process—it may be primarily a chemical process or primarily a mechanical process—did vary considerably. But if you carry out a good balance with the result that you know what you put in and what comes out, you can obtain in many cases the best answer as to what the emissions are. In many cases it is going to serve you far better than trying to analyze in a stack or in the atmosphere around a building to determine what the degree of pollution is.

Mr. Hanauer. Speaking as a control official, we would like to take Dr. Adams' approach to the industrial process but very often we find that the manufacturer would rather have his stack measured, so that nobody knows where the material in the stack comes from or how it got there or what is his process for making it. I'd like to assure manufacturers in general that control officials are the last people who would go into a competitive business. If we could approach the air-pollution problem with the manufacturer taking us into his confidence, we could certainly achieve more effective results.

Thomas Hunter. The question was brought up yesterday if some purple prose would originate out of this conference and Dr. Dixon said that within a hundred years gas masks might be as prevalent as shoes. That is rather purple to my mind and now I'd like to ask Mr. Hemen if these gases that are emitted from cars and trucks have a cumulative effect like radiation in the atmosphere or are they dispersed considerably?

Mr. Heinen. Dr. Dixon made me wonder what specific type of gas mask would be required for what specific pollutants. Certainly not for carbon monoxide and certainly not, as far as predictable at present, for organics; as I have indicated, we also need sunlight and oxides of nitrogen to bring about the reaction. In general, a good deal of nonsense, qualitative nonsense, has been issuing relative to the effect of automobile exhaust. Qualitatively it sounded real good. When you get down to specific numbers, then the statements don't seem to carry quite as much weight.

I am not saying we should not make every effort to limit exhaust emission. What I am saying is that I wish some of the writers of purple prose would take a little time out and put a plus or minus on their purple prose or put in a specific decimal point in identifying specific effects.

I have spoken today very, very quantitatively. In a conference of this type, my advice is: if it is not quantitative, disregard it.

Mr. Wurts. I would like to point out to Mr. Hunter, as a public relations representative of the trucking industry, that he could do a great public relations job if he would sell his industry and perhaps sell business, on the proper maintenance of their diesel engines. Because, if anybody gets behind a truck these days, the trucks speak for themselves. Or rather, they give visible evidence of what they are turning out into the atmosphere and from what I know about diesel engines, that is a matter of maintenance.

Thomas F. Williams. I did not hear Dr. Dixon's comments but a careful reading of his paper leads me to conclude that his prose in the last part is not in the least purple if it is taken in context. He speaks of population expansion, geometrical increases of people, of industrialization, of new processes, and of fuel usage—and it is not really very "purple" to use a slightly uncommon expression to dramatize the danger by suggesting the possibility of having to wear gas masks. I think there could be enough population expansion, enough industrialization, enough fuel usage to make the use of gas masks quite possible . . . provided we were not doing something about control. I think that's the implication. We are here, not to indict the automobile, but to make certain that the circumstances Dr. Dixon pictured do not have a chance to happen.

Mr. Heinen. When I say to disregard it if it is not quantitative, I mean to say that we need more quantitative information and we need more people in the laboratories. If there is one thing coming out of this particular session, I hope it is that there are very, very large areas in which we need more information.

I am not talking just about the automobile. I happen to be on the Surgeon General's Advisory Group and other problems are thrown at us, too. This whole question of establishing exactly what is in the atmosphere and exactly how it gets there is one which is just about in its infancy.

Now let's have more work in that area from all sources. If you don't want to publish it, at least do it, so that sooner or later when you get around to publishing it, it is available.

The problem of exactly how bad one source is, how bad another source is, may be a subject for questioning but the general fact that the atmosphere is being loaded is not a topic for questioning; it is a matter of fact.

DISCUSSION GROUP "C"
HEALTH EFFECTS OF AIR POLLUTION

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Dr. Reginald H. Smart, Chairman, Smog Committee, Los Angeles County Medical Association, Los Angeles, Calif.
Dr. Oscar A. Sander, Milwaukee, American Medical Association.

Theme

"What Are the Effects of Air Pollution on Health?"

Questions for Discussion

1. What do we know or suspect as to the effects of community air pollution on human health?
2. What should be done further, and by whom?

Exposure to High Concentrations of Air Pollution (1)—Health Effects of Acute Episodes

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Undoubtedly primitive man has always been overcome periodically or killed by fumes of burning materials when living in caves or other closed spaces with inadequate ventilation. This situation though not recorded in written history differs little from the thousands of acute carbon monoxide deaths due to unvented or poorly vented space heaters in cheap apartments and motels today.

The earliest written record of death from air pollution appears in the writings of Pliny [1] the Younger (first century A.D.). His uncle, Pliny the Elder, went by ship to see what was happening as the result of the eruption of Mount Vesuvius in 79 A.D. The old gentleman was the victim of chronic bronchitis or more extensive chronic pulmonary disease before the trip. Nearing the site he was overcome by "sulfurous fumes" and died on the third day after this collapse. The author also states that many in the Pompeii holocaust were "suffocated by sulfurous fumes."

There were undoubtedly other episodes of naturally occurring air pollution over the centuries due to volcanic eruptions, grass fires, and forest fires. These we shall skip for brevity because our major concern is manmade air pollution in an industrial society.

Complaints about foul air made as a result of man's effort to live a communal life and develop industry seem to have begun in earnest in England following the discovery and early mining of "Sea Coole" (coal) in 852 A.D.[2] Certainly mining was a regular operation by 1180 A.D. In 1306 a Royal Proclamation by Edward I and again in Queen Elizabeth's day (about 1570) prohibited the use of sea coal in fireplaces in London.[2] Apparently none paid much attention to these monarchs in this regard. Much of London's smoke problem, then as now, was a nuisance problem, yet there is a hint of illness attributed to fumes as early as 1661[3] The author, Mr. Evelyn, who seems to have composed the first book ever written on air pollution, attributed certain chronic disorders of the respiratory tract, particularly the lung, to the inhalation of coal smoke. He states as follows: "And what is all this, but the Hellish and dismal cloud of Sea-Coale? which is not only perpetually imminent over her (London's) head; . . . but so universally mixed with the otherwise wholesome and excellent Aer, that her inhabitants breathe nothing but an impure and thick Mist, accompanied with a fuliginous and filthy vapour, which renders them obnoxious to a thousand inconveniences, corrupting the Lungs, and disordering the entire habit of their Bodies; so that Catharrs, Phthisicks, Coughs and Consumption, rage more in this one City, than in the whole Earth besides." (Page D1.) For the most part, however, while man has complained bitterly about air pollution and attributed all manner of dire ills to it, real proof of illness in the general population caused by polluted air was lacking until recent years. The nuisance problem and the economic losses inherent in air pollution have been well documented for over one hundred years.

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[1] "Pliny the Younger (97-98 A.D.), The Letters of Pliny the Younger," Book Six (Plinii Caecilli Secundi L. Casius) Epistularum.

[2] Shaw and Owens, "The Smoke Problem of Great Cities," Constable, London, 1925. Page 2.

Definition

It is our purpose today to review the unequivocal evidence of acute illness produced by air pollution. However, since airborne disease may be of many varieties and of many causes, including bacterial, we must at this point define and limit our terms. For the purposes of this discussion, we shall limit ourselves to disturbances of health occurring in the general population due to contamination of the air by gaseous and/or particulate matter, either organic or inorganic but inanimate, produced in and by an urban industrial society. We shall exclude purely occupational disease and all forms of disease produced by living organisms of whatever character. (One must freely admit that certain industries could produce disease in the general population due to living organisms through air pollution, but to our knowledge, no such situation has been reported to date.)

Meteorology

Thoroughly to understand the pathogenesis of disease produced by air pollution, one must first familiarize himself with a few basic facts about meteorology. *First*, normally on a bright day with the wind blowing gently, the air of great cities is cleaned of its industrial gases and particulate waste by up-drafts of air which dilute it and blow it away. The particulate matter eventually settles over very wide areas. The gases are diluted infinitely and washed out by rain. *Second*, great masses of air move around the earth in a somewhat erratic fashion and in any one area this movement is a function of the barometric pressures, high, medium, or low, in that area. Occasionally mass air motion in any one area may stop for hours or even days. *Third*, not infrequently at night in some areas, particularly temperate zone river valleys, the temperature of the upper air may become warmer than the temperature on the surface of the ground. This is called a thermal inversion. Depending on the temperature differential, the height of the warm air, and the density of the warm layer, it acts as a lid preventing airborne waste from being dissipated in the usual manner. Waste then begins to accumulate. The smog banks one sees over nearly any great city, flying into it at dawn or dusk, are concentrations of airborne waste plus droplets of water held down on the city by a thermal inversion. *Fourth*, if this static condition lasts long enough and enough waste accumulates, it may become acutely toxic.

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[3] Evelyn, J., Fumifugium: or the Smoke of London Dissipated. 1661 reprinted by the National Smoke Abatement Society, London, 1930. (University of Michigan Library, vol. 614.7, E93f, 1930)

Other things one needs to know to understand acute disease due to air pollution are the basic principles which underlie the toxicity of any substance. *First*, a toxic gas or particle may be present in the air in concentrations which will never hurt anyone at any time. *Second*, they may be present in concentrations which will irritate but do no damage if the time factor is short enough. *Third*, they may be present in concentration and in time long enough to make some people ill (especially those already less than healthy) and not others. *Fourth*, they may be present in concentrations and time sufficient to make nearly everybody ill but kill only a few badly debilitated persons. *Fifth*, and finally, if the concentration and/or time are high enough, they could kill nearly everyone. In other words, there is a very specific time factor and a very specific dose or exposure factor for each toxic substance. For carbon monoxide, it is one thing; for nitric oxide, quite another; and for iron dust, still another. Also the age and state of health of the individual exposed play a role in the outcome when an individual is exposed to any given toxic chemical.

Smog-Caused Epidemic Disease

With these bits of miscellaneous information in mind, let us examine three great epidemic episodes of illness due to contamination of the air by manmade airborne toxic waste, which has been recognized, studied (after the fact), and well documented. These occurred in the Meuse Valley of Belgium in 1930, in Donora, Pennsylvania, in the Monongahela Valley in 1948, and in London, England, in 1952.

Meuse Valley.—During the first week in December 1930, all of Belgium was blanketed by fog (static air full of droplets of water each of which contained one or more dust particles). This was most marked in the Valley of the Meuse, and in it there was also a thermal inversion. In a 15-mile area of this valley, there were many factories, including coke ovens, blast furnaces, steel mills, zinc mills, glass mills, powerplants, and a plant making fertilizer and sulfuric acid. All the homes in the area were heated by coal; the steamships on the river were powered by coal as were the freight trains. Trucks were not numerous then. Beginning on the third day of this abnormal weather, with static air and no up-draft, people became ill of a respiratory disorder. Somewhere around 6,000 people became ill and perhaps 60 died over the next 2 days. When rain came and the fog disappeared, the epidemic stopped instantly; there were no more new cases.

Donora.—During the last week of October 1948, static air, anticyclone weather conditions, plus thermal inversion, occurred over most of the entire eastern half of the United States. This was particularly marked in the upper Ohio River and in the lower Allegheny and Monongahela River Valleys. This area, as all know, is full of heavy industry. In Donora, Pa., on the Monongahela River, there is another factor. The city lies on a U-shaped river bend and unlike its neighbors has high stone hills, up to 1,100 feet, on four sides whereas its neighbors, Monongahela City and Monessen, have them only on two sides. Like the Meuse Valley, there are blast furnaces, steel mills, zinc mills, H_2SO_4 mills, and slag processing mills in Donora. Donora has dense smog (fog-smoke mixture) every morning, but normally it is gone by 10 a.m. or at least by noon. Again by the third day people became ill, 5,910 of them, and 18–20 died. Again also there was a rain on Sunday after Halloween and the epidemic stopped immediately.

London.—In the week of December 5–9, 1952, much of the British Isles was enveloped by dense fog caused by anticyclonic conditions and a thermal inversion. The broad Thames Valley and especially London were severely involved in this weather abnormality. Much illness and a significant rise in death rate occurred which was not fully recognized till after the fact. This is by no means the first severe episode in London, but it is the most fully documented and is therefore selected for this presentation.

Illness began within 12 hours after the onset of dense fog. It was respiratory in character as were the other two reported above. There are no exact figures on morbidity, but the mortality statistics reveal about 4,000 deaths in excess of the expected number in London for that week.[4, 5, 6] It is evident that the mortality rate was much higher in the London episode than in the previous two episodes because if it were not, extrapolating from Donora's experience, there would have been about 1 million persons ill in that week—a situation which could not have escaped wide public recognition.

In London also the mortality was shared by all age groups—not just the very old and very young. As in the other two episodes, most of those who died were recorded as having chronic bronchitis, broncho-pneumonia, other lung disease, or heart disease. Most of the deaths in all three episodes occurred in chronic cardiopulmonary invalids.

The data on animal deaths in the Meuse Valley and in Donora are incomplete. All manner of animal deaths are attributed to the smog by local citizens, but few facts emerge. In London, however, there was a large animal show. Sheep and pigs had no difficulties. Cattle suffered severely and many died or had to be killed—usually the most highly bred ones. There were no casualties at the London Zoo. The horse farms were unaffected as were the small animal hospitals. No good data are available from chicken farms or on household birds, both of which had difficulty in Donora and the Meuse Valley.

The nature of the disease process in all three episodes was similar. Onset was abrupt in well people and the increase of symptoms of the chronically ill was sudden and without apparent cause. There was burning of the eyes, nose, and throat, followed by cough, shortness of breath, constriction and burning in the chest, wheezing respiration,

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[4] Logan, W. P. D. Lancet 1:336, 1953.

[5] Fry, J. Lancet 1:235, 1953.

[6] Anonymous. Reports on Public Health and Medical Subjects No. 95, London, 1954.

often nausea and vomiting, and in the severely ill, collapse and cyanosis.

In all three episodes extensive studies were made *after the fact* to determine cause. In the Donora disaster, these studies were exhaustive; they were carried on over a period of nearly 2 years, and were independently done by the U.S. Public Health Service and the Kettering Laboratory of Cincinnati for the United States Steel Corp. They involved a study of all meteorologic data available back to about 1918, and a critical review of all mortality and morbidity data available from the Pennsylvania Department of Health for the same period. House-to-house study was made by trained epidemiological investigators and as many autopsies were obtained as possible, including exhuming two of the buried deceased. A critical analysis was made of all material coming into the city, all products going out, and the physical and chemical nature of all waste products from mills, homes, incinerators, etc. Smoke stack effluent temperatures and air movement rates were measured. All air-cleaning gadgets operating in the city during the episode were cleaned and their dust collections studied. By ingenious supersleuthing, some of the air in Donora on the worst night of the episode was retrieved from a large truck tire and a tank railroad car. Biologic studies of acute and chronic plant damage were made. Scale models of the community and the surrounding valley were made. All unusual episodes up and down the river such as house fires and explosions were exhaustively investigated. Subsequently extensive research was initiated and is still going on to answer unsolved problems. Similar but less extensive studies were made in the other two areas.

The official conclusions reached in the Meuse Valley are paraphrased as follows:

> Maximum fog caused the illness of many thousands of persons and the death of at least 60. The aged were affected more frequently and more severely than the young. The elements in the maximum fog were probably acid gases adsorbed on the surface of particulate matter which, when it got into the tracheo-bronchial tree and lung, were hydrolized to their respective acids causing chemical irritation and/or burns of the lining membranes. These materials are the result of the combustion of fuels and manufacture of metals in the valley in which the episode occurred.[7]

The official conclusions of the U.S. Public Health Service Report No. 306 on Donora are quoted in part as follows:

1. “During the smog of October 1948, a total of 5,910 persons or 42.7 percent of all persons in the Donora area, were affected to some degree by the smog.

2. “The affection was essentially an irritation of the respiratory tract and other exposed mucous membranes, and varied in degree from mild to severe. Cough was the predominant single symptom during the illness.

3. “Neither incidence nor severity of affection apppeared to be influenced by sex, race, occupational status, length of residence

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[7] Dehalu et al. The Causes of the Symptoms Found in the Meuse Valley During the Fogs of December 1930. Bul. acad. royale de med. de Belgique. 11: 683, 1931.

in the area, or degree of physical activity at the time of onset of affection.

4. "Both incidence and severity revealed a direct relationship with increasing age. Over 60 percent of persons 65 years of age and over reported some affection from the smog and almost one-half of these were in the severely affected group.

5. "With the exception of such episodes as that of the October 1948 smog, long-term studies of mortality records and plant morbidity records indicate that the health of the people of Donora appeared essentially no different from that of nearby towns.

6. "Twenty persons died in the Donora area during or shortly after the smog of October 1948; 17 died on day number 3.

7. "Among the autopsies performed there were three of persons who died during the smog and these showed acute change in the lungs characterized by capillary dilatation, hemorrhage, edema, purulent bronchitis, and bronchiolitis."[8]

And from London, the British Government reports tersely as follows:

> "While the available evidence does not allow of a clear indictment of any one constituent of the fog, the conclusion is inescapable that the excessive mortality and increased incidence of respiratory illness during and immediately after the fog of December 1952 were the result of irritation of the respiratory tract by contaminants of the fog. The irritants mainly responsible were probably those derived from the combustion of coal and its products and their lethal effects were wholly exercised in persons already suffering from chronic respiratory or cardiovascular disorders."[9, 10]

If I have given the impression that these three epidemics of disease were completely identical, I have erred. They were not. In London, age specific mortality rates were different from the other two by a wide margin. The list of possible air contaminants in each of the three areas contains materials not found or not likely in the other two both qualitatively and quantitatively. Animal and crop damage was probably not identical in even two of the three.

Yet certain facts are clear and they apply to all three episodes:

1. There were anticyclone weather conditions in all three.
2. There were thermal inversions in all three.
3. There was dense fog in all three.
4. The thermal-lid on each valley was incomplete and did not hold all aerial waste in the valley.
5. There were vast quantities of particulate matter in the air—mostly carbon and iron dusts.
6. There were vast quantities of gases of various kinds, mostly oxides of carbon, sulfur, and nitrogen, in the air.
7. The particulate matter in the air adsorbed a good deal of acid gas material on its surfaces.

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[8] Air Pollution in Donora, Pennsylvania. U.S. Public Health Service Bulletin Number 306, 1949.

[9] Beaver, H. Interim Report, Committee on Air Pollution, London, 1953.

[10] Ibid. London, 1954.

8. The concentration of no known single chemical substance reached presently recognized lethal levels.

9. The toxicity of mixtures of dusts and gases in nonlethal or even nontoxic concentration is unknown.

10. No single cause of morbidity or mortality was found.

Curiously enough the investigators of each episode considered ozone as a possible single cause of symptoms and in each it was discarded because its high reactivity would preclude any free O_3 in an atmosphere full of unoxidized or incompletely oxidized dusts, gases, and fumes. Yet excellent work done by Hans Klauman [11] at Randolph Air Force Base in Texas shows clearly that the symptom complex of ozone intoxication is identical with that reported in the Donora and Meuse Valley episodes and ozone or like material plays a definite role in Los Angeles smog as we shall see subsequently.

Finally, before leaving these three major episodes we must ask, "Is each unique in that area? Had the situation occurred before and been unrecognized?"

In London, for years, it has been possible to demonstrate a very high degree of correlation between death from cardio-respiratory disease and the intensity of smog. In Donora there were many brief meteorologic episodes which contained the necessary elements for trouble except that the time element was too short. There were two other situations lasting long enough to do real damage but they happened to occur in the first instance before the city had fully developed industrially and in the second, at the time of a long shutdown during the economic depression of the 1930's.

Given the proper geography, meteorology, and industrial concentration, such episodes can occur almost anywhere, but usually will be in river valleys.

Other Episodes

In addition to these three major episodes there have been other instances of damage to health from air pollution.

In 1949 in Cincinnati a small plant which sulfonates oils was expelling some hydrogen sulfides on a rainy day. A very slow-moving cloud passed over the exhaust stack during this time and collected within it a great deal of this gas. The cloud subsequently slowly passed across Reading, Ohio, blackening all lead house paints on houses in an area 100 feet wide and one-half mile long. The time was early morning and some folks in the path were still in bed with windows open. The nauseating odor disturbed all and caused nausea and vomiting in a few children. No serious nor permanent damage was done.

In Poza Rica, Mexico, on November 24, 1950, an unusual exposure by hydrogen sulfide caused illness in 320 persons and death in 22.[12, 13]

In 1955 and 1956, a small chemical plant in Gallipolis Ferry, W. Va., began to emit mercaptans as an airborne waste. The prevailing wind is from the plant area northeast to the city of Gallipolis, Ohio. On foggy or thermal inversion mornings, the odor was so strong as to cause school children and a few housewives to vomit. No permanent damage has been reported. These three situations differ from the first three in that in each the specific cause of illness is known and has been dealt with in a manner which will prevent a repetition.

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[11] Klauman, Hans. Toxicity of Ozone, Paper Presented at the Ohio State University Postgraduate Course in Aviation Medicine. September 1955. Not published.

[12] McCabe, L. C. Industrial and Engineering Chemistry. 42: 79a, 1951.

[13] McCabe, L. C. Archives of Industrial Hygiene and Occupational Medicine, 6: 199, 1952.

Many persons in the audience will be somewhat familiar with the smog problem of Los Angeles, Calif., which has been plaguing that great city for over 10 years.

At certain seasons, because of offshore anticyclonic weather and an over-the-city thermal inversion, concentrated air pollution becomes very intense. Many complaints of disorders of health due to it have been made. However, there is no evidence of increased morbidity in any age group nor any increased mortality even in the chronically ill during these periods. There is, however, very definite eye irritation with inflammation and tearing and some nasal irritation.

Here, very extensive study has shown that incompletely burned petroleum products are the chief contaminants. Automobile exhausts play a major role. Ozone and ozone-like materials are in the air in good-sized quantities and are contributed by the high ultraviolet content of the sunlight in that area. There are also measurable concentrations of sulfur oxides, nitrogen oxides, and carbon monoxide. Recent research suggests that none of these causes the eye symptoms. They may, however, be due to the combination of unsaturated olefin compounds, which in the presence of ultraviolet light combine with nitrogen oxides to form a previously unrecognized irritant.[14]

Conclusion

From these seven situations it may be seen that air pollution can produce and has produced serious illness and even death. However, since all industrial cities, the world over, produce air pollution in tons per day all the time, and since there are only a handful of authenticated episodes of acute illness due to it, one must also conclude that acute illness and/or death due to air pollution is unusual. The thing which seems to make air pollution suddenly dangerous is weather, a very particular kind of weather. Such acute situations are now predictable. Such disasters are preventable. However, let us be very careful indeed as we go about the business of the prediction and prevention of such episodes lest we destroy our very way of life. Where there is industrial prosperity there will forever be industrial wastes of some sort. How they will be minimized to types and quantities which will never injure the health of man, plants, or animals is a complex matter to be dealt with with great care, and with a high degree of intelligence.

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[14] Personal Communication—Los Angeles County Air Pollution Control District.

Exposure to High Concentrations of Air Pollution (2)—Discussion of Dr. Ashe's Presentation

Dr. Robert A. Kehoe
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Cincinnati, Ohio

It would give me a certain amount of satisfaction, without animosity, to be able to find some serious fault with Dr. Ashe's presentation. The subject, however, has been presented fairly and fully; and, so far as its factual information goes, it is applicable. I shall follow my own advice to other doctors not to indulge in speculations, and confine myself to some things that we know about and to suggest that we need to know more. We will not know very much more about these situations by mere talking. If we are to learn more about them, we must do more work to discover more and more information.

There are certain aspects of the Donora situation, and of the London situation, which do require further elucidation. Among these is the problem of composite effects of a considerable number of materials, gases, and particulate matter together. I shall not go into detail, but I wish to point out the general problem with which we are faced, of determining more fully the consequences of the composition of the atmosphere with reference to a variety of materials which may influence each other in various ways.

Having mentioned this first, I shall leave it and call attention to another aspect of the discussion of these acute situations, namely, with reference to where we put the blame for them. In the simplest of these, the Cincinnati incident, for example, of which Dr. Ashe spoke—and I think that there have been many of these in various parts of the country and that, despite Dr. Ashe's optimistic statement that these have been disposed of, there will be others like them in the future—it is easy to put the blame in the proper place. Accidents, human failures, failures of equipment in connection with industrial operations, and certain other community operations may pour into the atmosphere significant quantities of dangerous materials. This is one of the situations in the field of air pollution which we can understand fully. In these we can visit the blame or the responsibility very much where it should be.

Only in the case of certain others, as, for example, the Los Angeles situation, which we might credit perhaps mainly, at least in certain of its aspects, to automobile exhaust gases, the problem is yours and mine, the drivers of automobiles. Then it comes back, of course, to the manufacturer of automobiles and to the manufacturer of fuel. My point is that on this matter we cannot find a whipping boy or scapegoat. We have to analyze the problem. We have to establish what are the facts, and we have to find an intelligent approach to the solution.

Still more serious is the problem of an old city, London, with the participation of all of its citizens in contributing to the contaminated atmosphere, which results in harm for those who are already somewhat disabled.

The only further contribution that I think I can make to this discussion is to suggest that we must stick patiently to the investigation, to the elucidation of these things point by point, factor by factor, situation by situation, and find by means of appropriate and faithful investigation the answers that we need for the solution of our problems. I have complete confidence that when we have these answers in such a form as to demonstrate what must be done, we shall find the means of doing it. We shall find responsibility within industry; we shall find responsible administrators; we shall find responsible people within the community—citizens who, once properly informed, can generally be counted on to take appropriate action.

Our difficulty in this situation is that it has come upon all of us in various parts of the country as a consequence, as Dr. Ashe has said, of a way of life which we have adopted, upon which our economy is based. We shall have to apply the same skill and the same devotion to its solution that we have contributed to its production.

By our cleverness in technological matters, we have created around us a new and, in every respect, a dangerous world. By our responsibility and wisdom in the control of our own acts, we may suitably find the means of bringing health and safety to our people in a situation which is properly our concern.

Exposure to Low Concentrations of Air Pollution (1)—Health Effects From Repeated Exposure

Dr. Lester Breslow
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State Department of Public Health
Berkeley, Calif.

Advances in technology over the centuries, aimed at improving man's environment, have ironically left in their wake a certain amount of damage to man's health. We are only beginning to assess the nature and amount of this health injury.

As we do so, two things are becoming clear. One is that chronic, sometimes fatal, diseases may result from exposure to environmental conditions. The old idea that chronic diseases are "degenerative," or inevitable concomitants of aging, is giving way to the modern idea that the origins of chronic disease lie in specific external causes which can be discovered and thus controlled.

The other thing we are learning is that many environmental conditions, which man repeatedly experiences, only gradually reveal themselves as dangerous to health. Chronic diseases are so insidious in their onset, and causative mechanisms so subtle that decades may elapse before cause and effect are put together.

Two brief illustrations may be useful here. One is coal miners pneumoconiosis, a disease characterized by replacement of normal lung tissue with scar tissue. For many years physicians considered that while coal dust was "dirty" and even caused certain changes in the lungs, it did not seriously affect health. Recent investigations by English workers have demonstrated that coal dust does cause extensive disease in some persons, disease that may terminate in death. Studies show that coal miners above the age of 40 years who have this condition in an aggravated form, suffer a greater than 50 percent loss of lung function as compared with the normal, nonminer population. Even miners without clinical evidence of the disease have somewhat impaired lung function.

Another example is cigarette smoking and lung cancer. Millions of persons had been smoking cigarettes for several decades before we became aware that it was an important factor in this fatal disease. Now the evidence is overwhelming and we face the tremendous task of doing something about it.

Many other examples could be cited to emphasize the fact that conditions which appear for many years to be harmless may ultimately prove to be inimical to health.

The scientific method used extensively to work out these problems is known as epidemiology. It focuses on *populations* rather than on individual cases of disease. Epidemiology is particularly helpful when studying insidious or delayed effects of harmful agents. The epidemiologist studies the experience of a whole population and then various segments of it—e.g., coal miners or cigarette smokers—to determine whether the disease condition in which he is interested may be associated with a particular environmental exposure. The first aim is to verify or disprove such a relationship. If the relationship is established and a particular population group thus proved to have a higher risk, then the task is to ascertain the precise environmental circumstances, e.g., the chemical or physical agents which are involved in the causative process.

In this latter aspect of the work, laboratory investigators play the prominent role. They determine the exact chemical substance, size of particle, mode of action, and other details which make control efforts more specific. Thus epidemiological research on people living in their everyday environments and laboratory research often using animal experimentation are two arms of research which complement one another.

Now it may be useful to consider more indirectly the question, where do we stand in respect to the effect of long-term exposure to air pollution? At the outset it is necessary to recognize again our British colleagues, this time for work on the disorder which is so common in their country, chronic bronchitis. Dr. Carey will speak in detail about investigations of this condition. It will suffice here to note that this modern plague of England and Wales is definitely more frequent and worse among persons exposed for years to air pollution caused by the burning of large quantities of coal for heating and other purposes.

However, in the United States, particularly in California, where air pollution originates largely from burning petroleum, studies to date have not disclosed such a clear-cut relationship to chronic bronchitis. We are investigating the problem further, seeking to determine whether episodes of air pollution or long-term residence in air-polluted areas aggravate the disease. Recently our studies have expanded to include measurement of actual lung function as well as the frequency and severity of clinical disease. In view of the British findings this type of work assumes a high priority.

Another important lung disease that has been related in some instances to air pollution is asthma. "Yokohama asthma" was the name given to a disorder recognized early in the winter of 1946 by American servicemen and their dependents in Yokohama. The preceding year many of the personnel had experienced a mild bronchitis; in 1946 they had attacks of wheezing and shortness of breath typical of asthma. Most of those afflicted had no history of allergy. The attacks occurred during a period of low winds and high air pollution. Japanese have also noted these symptoms and a similar disorder has been reported from Okinawa.

American newspapers carried only a few weeks ago the story of another in the series of outbreaks of asthma in New Orleans. The epidemiological picture is a sudden large increase in the number of persons seeking hospital attention for asthma attacks, starting late in the evening and continuing for several hours thereafter. It is difficult to conceive of any factor that would have such an effect other than some sudden change in the environment, probably in the atmosphere. Studies of the phenomena are going forward.

In experiments during which human volunteers were exposed to sulfur dioxide and sulfuric acid mist, two of the experimenters developed increasing sensitivity to these substances. One of them developed a persistent bronchitis which progressed to the point where coughing and wheezing occurred on exposure to either agent. The other investigator developed symptoms of wheezing which continued 4 days after his exposure. The resemblance of these "accidental experiments" to the Yokohama or New Orleans type of asthma is close enough to warrant further study.

In Los Angeles some physicians have maintained that their patients with asthma are prone to suffer attacks during smog episodes. An investigation in which the State Department of Public Health cooperated with a group of these Los Angeles physicians was based upon the recording of all attacks by patients over a several-months period. In Pasadena, an area with high air pollution, this study failed to substantiate the notion that, in general, asthmatics had more frequent or more severe attacks during episodes of air pollution.

Emphysema is a third chronic lung condition deserving attention as possibly related to air pollution. It is the end-result of disease which gradually enlarges the tiny air sacs where the oxygen exchange between blood and air takes place. In emphysema these sacs, because of chronic obstruction in the pathway to the lung, become larger and confluent. Ultimately much of the airspace in the lungs is "dead." Function of the lung is thereby reduced, sometimes to the extent that either a slight infection or some extra load on the heart (which must compensate in part for the lung failure) will result in death.

It is of particular interest that the rate of deaths attributed to emphysema has been rising sharply in recent years. In California the rate has jumped from 1.5 deaths per 100,000 persons in 1950 to 5.8 per 100,000 in 1957. Comparable increases are occurring in some other States. A lot of questions immediately occur. First of all, is this 400 percent rise a true increase in the disease or does it merely mean that the diagnosis is becoming more popular with physicians, perhaps replacing other diagnoses that would have been specified for the mortality tables in earlier years? If the increase does prove to be real, then one must ask whether it is related to the type of metropolitan air pollution that has been growing sharply in many United States cities since about 1940. In the cities of the United States the mortality rate from emphysema is about twice as high as it is in the rural areas. It should be emphasized that we are by no means in a position to draw any sound conclusions about this matter. But the facts demand intensive investigation.

One laboratory approach to the question of whether smog-type air pollution has an effect on emphysema has been undertaken by Dr. Hurley Motley, in Los Angeles. He has found that some persons with severe impairment of lung function, when taken out of polluted air into a room with cleaner air (filtered through an activated charcoal filter) show improvement in their lung function. This work indicates that air pollution of the Los Angeles type may have some adverse effect on emphysema; it also suggests a method whereby the problem can be further investigated.

Lung cancer also must be considered from the standpoint of air pollution. Drs. Paul Kotin and Thomas Mancusco will be discussing this in detail but two important aspects of the causation of lung cancer as presently understood by epidemiologists should perhaps be mentioned here. The first is that cigarette smoking, considered by most epidemiologists to be an important causative factor, will not account for all the lung cancer that occurs, since some nonsmokers do get the disease. Secondly, lung cancer rates are substantially higher in cities than in rural areas, and differences in cigarette smoking between city dwellers and rural people will not explain all the difference.

Recently there have been some animal experiments involving long-term exposure to air pollutants. One difficulty in such work lies in interpreting the significance to humans of findings in animals. Despite such problems, there is need for a substantial increase in animal experimentation to advance knowledge of the biological effects of air pollutants. In one investigation four different species of animals—hamsters, rats, guinea pigs, and dogs—were exposed to one part per million of ozone for 6 hours per day for about 1 year. Microscopic examination of the lungs thereafter showed marked fibrosis and destruction of airway lining cells in guinea pigs. Similar but less marked changes occurred in rats and hamsters, but no damage was observed in the dogs.

This study indicates that subtle changes may occur due to repeated exposure to levels of ozone which are not much above the levels occurring frequently in Los Angeles smog. In their reaction to ozone it is not possible to say whether men more closely resemble rats, guinea pigs, hamsters, or dogs.

A more direct indication of the effect of air pollution on human health comes from the California Health Survey in which, during 1956, a representative sample of adult persons living in the State were asked a number of questions pertaining to air pollution. Questions incorporated into the survey covered various aspects of health and social well-being.

For example, people were asked how satisfied they were with the community where they lived and, if dissatisfied, to give their reasons for being dissatisfied. They were also asked to what extent, if any, they were bothered by air pollution in their home communities and whether or not they had given any serious thought to moving their residence because of air pollution. Three-fourths of the adult persons living in Los Angeles replied "yes," that they were bothered by air pollution either at home or at work or both, and indicated that it bothered eyes, nose, throat, or dispositions. Elsewhere in California less than one-fourth of the population stated that air pollution bothered them either at home or at work in 1956, although air pollution has been spreading into different parts of California since that time. In general, both community dissatisfaction and job dissatisfaction were higher among those who were bothered by air pollution. Of all adults interviewed, 6 percent reported they had given serious thought to moving out of their communities because of air pollution and this figure was twice as high for Los Angeles County. Although this figure may seem low percentagewise, it represents some 780,000 adults in the State population, the vast majority of whom live in Los Angeles County. At least 11 percent of the moves out of Los Angeles County during the years 1947–56 were attributed to air pollution as compared to only 1 percent prior to 1947.

These data begin to give a quantitative view of the extent to which air pollution disrupts people's lives. Such long-continued interference with comfort and well-being, some of it sufficient to cause people to change their residence and jobs, certainly represents an important threat to health. Haagen-Smit has correctly termed it a "community sickness."

The findings of the several investigations briefly reported here add up to a substantial justification for concern about the long-term effect of repeated exposure to air pollution. Evidence is gradually accumulating which suggests that air pollution of various types, chemically and physically, may be involved in such important lung conditions as chronic bronchitis, asthma, emphysema, and lung cancer. Experimental animal work demonstrates adverse biological effects from air pollutants. And health surveys are beginning to quantify the important socio-psychological effect on humans which any long-time resident of Los Angeles can assure you is no laughing matter.

From the standpoint of long-term effect of exposure to air pollution, an urgent need is to step up research—both epidemiological and laboratory research—to determine the nature and extent of damage to health, and the specific air pollutants which are responsible for it. Only in this way can control efforts ultimately be pinpointed to assure the prevention of health damage. In the meantime, of course, air-pollution control efforts should be pressed energetically on the basis of present knowledge.

Exposure to Low Concentrations of Air Pollution (2)—Discussion of Dr. Breslow's Presentation

Dr. Leonard M. Schuman
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It is gratifying to note the emphasis which Dr. Breslow has placed upon the need for intensified epidemiologic research into the long-term chronic effects of repeated low-dose exposure to air pollutants. The task is not a simple one for, as has repeatedly been stated, chronic illnesses are insidious in their onset and their etiologies remain, at best, remarkably obscure. The elusiveness of cause-and-effect relationships is merely a function of the insidiousness of chronic diseases, for they stand at the opposite end of the spectrum from acute disease with its dramatic onset and easy association with environmental cause. A chronic disease may have had its incitant cause or causes acting years before and these may no longer exist in the victim's present environment. Only through the epidemiologic approach, taking cognizance of these variables, can we hope to unravel these complicated mechanisms in the population.

Breslow has indicated that, once a group diagnosis has been reached in a population, laboratory investigators take on the prominent role in eliciting the chemical or physical agents involved in the causative process. Until relatively recently, complete reliance in unraveling cause-and-effect relationships had been placed on the toxicologic laboratory. Basic though such investigations may be, and important as they are to our understanding of physiologic mechanisms in acute and chronic exposures to pulmonary and other system irritants, they must frequently await clues derived from epidemiologic studies of the population, especially on chronic exposure effects.

There exists a tendency among a number of groups to sidetrack epidemiologic study for direct control applications. Although the evidence gained from a number of air-pollution disasters has been relatively clear-cut and warranting the application of specific controls, the problems inherent in long-term chronic effects of low-dose exposures are not so clear and not readily verifiable. We must not allow the glamor of the means to obscure our need for defining the ends. Health agencies have all too frequently fallen into the sin of perpetuating "sacred cows" without stock-taking. It behooves us first to evaluate the relative dangers of the several aspects of air pollution. This can be done epidemiologically, and epidemiologic inquiry can serve to guide control applications. This is not intended to imply that engineering research shall not go on apace, with controls applied where obviously needed.

Health agencies, especially those which are tax-supported and which perennially are short of funds, must have scientific justification for expenditures in air-pollution control. Nor will industry accept every mandate without scientific support. This does not imply that we must wait for final irrefutable verification of cause-and-effect relationships in such situations as Donora, or London, but it does imply further substantiation of the more subtle relationships between milder smogs and lung cancer, chronic bronchitis, and asthma. Without epidemiologic guidance of control work, we may be, as Breslow recently wrote, "seeking to protect the taste and appearance of the water without destroying the typhoid bacilli."[1]

Furthermore, studies in one country or in one area of a country are not necessarily translatable into action in another. Epidemiologic techniques applied analytically to two diverse experiences may yield the common denominator for both—an associative relationship not elicitable from either separately. The chronic effects of repeated low-dose exposures to an irritant may be totally unlike the acute effects of massive short-acting doses. In nitrogen dioxide poisoning, massive doses yield acute death from pulmonary edema or delayed death from bronchiolitis fibrosa obliterans, whereas the former (repeated low-dose exposure) may produce chronic bronchitis, pulmonary emphysema and/or fibrosis, and even, eventually, cor pulmonale.[2] These latter hypotheses are presently being explored by us in connection with silo-fillers' disease both in the laboratory, toxicologically, and in the field, epidemiologically, seeking to elicit excess chronic pulmonary disease among farmers with moderate to high potential exposures to silage gas as compared to those with little or no exposure.

Studies of this type, though dealing with an occupational type of exposure limited to a "microlocale," may yield clues to assist in the unraveling of the subtle effects of low-dose repeated exposures such as may occur in community air pollution. Although large-scale studies of chronic disease differentials among communities with varying intensities of air pollution are clearly indicated and highly desirable, we cannot afford to overlook epidemiologic studies of single entities in more or less delineated situations such as Yokohama or New Orleans asthma, farmer's lung in Wisconsin, or nitrogen dioxide poisoning in silo-fillers.

Exposure to Low Concentrations of Air Pollution (3)—Chronic Bronchitis in Relation to Air Pollution in Great Britain

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In England and Wales some 45 million people live in an area about the same size as the State of Michigan and a large proportion of these people are concentrated in very heavily populated industrial areas. About 200 million tons of soft coal are burned each year and the overall level of pollution in these industrial areas is much higher than that experienced in most American cities. Examination of the vital statistics for the United Kingdom shows that the disease commonly known there as "Chronic Bronchitis" has a much higher incidence in smoky cities than in country areas. Even more important is the fact that the incidence of this disease, more than any other, increases very sharply as one goes from the relatively clear air of the country districts, through suburban areas, to the centres of the large industrial conurbations. Other factors concerned in the production of chronic bronchitis appear to be cigarette-smoking, population density and domestic overcrowding, low socio-economic status, a history of chest disease in the family, and sex (men develop the disease rather earlier than women).

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[1] Breslow, L. and Goldsmith, J.: Health Effects of Air Pollution. Am. J. Pub. H. 48: 913–917, July 1958.

[2] Lowry, T. and Schuman, L. M.: Silo-Fillers' Disease—a Syndrome Caused by Nitrogen Dioxide. J.A.M.A. 153–160, September 15, 1956.

Now, what is "chronic bronchitis"? Chronic bronchitis has cough and the production of excessive amounts of sputum (often containing pus) as its outstanding symptoms. The diagnosis of this disease should not be made until other forms of lung disease such as cancer, tuberculosis, and lung abscess have been excluded, and the patient has had increased cough and sputum either in the winter months, or all year round, for a period of not less than 3 years.

British general practitioners[1] say that about 10 percent of their work deals with chronic bronchitis and their workload from this disease is 10 times greater in December than in the summer months. About 30 percent of the patients suffering from chronic bronchitis have excessive cough and sputum containing pus in the winter but they can usually continue to work. Another 30 percent of patients have more severe symptoms which involve periodic absences from work. Yet another 30 percent of patients have symptoms all year round and are so short of breath that their working capacity is greatly reduced. The remaining 10 percent of patients are mostly men who are complete invalids, unable to work, and who usually die from heart failure or from some additional respiratory infection.

Chronic bronchitis is an important cause of sickness absence in British industry, in which 27 million man-days were lost in 1951 from this cause in an insurable population of 25 million persons, a figure 8 times as high as prolonged sickness absence from the common cold. The actual impact of chronic bronchitis on the community is greater than this, as there are another 20 million persons in the country not covered by unemployment insurance, such as housewives, children, and certain professional groups.

Comparative Statistics With Other Countries

Comparison of the incidence of chronic bronchitis in different countries is complicated by factors such as local customs in medical diagnosis, incomplete reporting of sickness absence or mortality, and by wide differences in social conditions, air pollution, and climate. It is clear that England has the highest reported incidence of chronic bronchitis (65 per 100,000) and the United States one of the lowest figures (2 per 100,000), with the Scandinavian and Central European countries intermediate (10 to 20 deaths per 100,000).

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[1] Fry, J. (1954): "Chronic bronchitis in general practice" Brit. Med. J. 1, 190.

Air Pollution Studies in the United Kingdom

The effect of air pollution on the health of the British people is being studied in two ways:

1. *Retrospective studies of previous smog disasters.*

Four major smog episodes [2, 3, 4, 5] have occurred in London since 1948 and each was followed by an increased number of deaths when compared with the mortality experienced in the same weeks of smog-free years.

Nearly 600 excess deaths occurred after the fog of November 1948, 2,000 deaths after the much publicized fog of December 1952, 500 deaths from another fog in January 1956, and 400 deaths in the most recently reported incident, that of 2d–5th December, 1957. If deaths occurring in the towns on the periphery of the London area are also included, the total deaths following each fog episode are probably twice the figures mentioned. The members of the population most susceptible to the effects of smog have been shown to be very young children, old people, and persons suffering from severe heart and lung disease.

Fairbairn and Reid (London School of Hygiene)[6, 7, 8] have studied mortality in the general population of Britain between the ages of 45 and 65 and report that deaths from bronchitis are significantly related to visible smog, population density, and domestic overcrowding. They also found that deaths from pneumonia in men were also significantly related to fog and to population density. Deaths from cancer of the lung and from pulmonary tuberculosis were not related to fog, but did bear a significant relationship to population density.

The health records of mailmen working in Britain were also examined and have shown a very significant correlation between visible fog and sickness absence and "bronchitis wastage" (by which is meant mailmen dying in service, or prematurely retired, from chronic bronchitis). Compared with the sickness experience of a 3 percent random sample of male and single female civil servants of executive and clerical grade, the pneumonia and bronchitis rates of mailmen in the 7-year period 1946–53 were much higher than their fellow workers indoors, the rates in indoor workers being similar to those of outdoor mailmen who were 20 years younger.

2. *Prospective studies relating to the effect of air pollution on human health are being carried out by three different research groups.*

(a) Dr. P. J. Lawther is following the health of some 200 chronic bronchitis patients at St. Bartholomew's Hospital wards and out-

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[2] Logan, W. P. D. (1949): Fog and Mortality. Lancet 1, 78.

[3] Ministry of Health (1954): Mortality and Morbidity during the London Fog of December 1952. Reports on Public Health and Medical Subjects No. 95 H.M.S.O. London.

[4] Logan, W. P. D. (1956): Mortality from fog in London. Brit. Med. J. 1, 722.

[5] Bradley, W. H., Logan, W. P. D., and Martin, A. E. (1958): The London fog of December 2–7, 1957. Mon. Bull. Min. Hlth: 17, 156.

[6] Reid, D. D. (1958): Environmental Factors in respiratory disease. Lancet 1, 1289.

[7] Reid, D. D. and Fairbairn, A. S. (1958): The natural history of chronic bronchitis. Lancet 1, 1147.

[8] Fairbairn, A. S. and Reid, D. D. (1958): Air Pollution and other local factors in respiratory disease. Brit. J. Prev. Soc. Med. 12, 94.

patient clinics. He has published interim reports[9, 10] that these patients tend to feel worse immediately before the onset of visible fog, and that their symptoms also increase and decrease in exactly the same pattern as do simultaneous measurements of smoke and sulfur dioxide. Dr. Lawther's group is also engaged in the study of the physical and chemical nature of London fog.

(b) A very comprehensive survey has been undertaken by the Medical Research Council group working at the University of Sheffield under Prof. John Pemberton.[11] Daily measurements of smoke, temperature, humidity, and gaseous acid are obtained from 29 sampling stations in Sheffield operated by this M.R.C. group or by the city authorities. These air-pollution measurements are being compared with the health of the population of the city and provide a basis for the three following simultaneous surveys.

(1) The effect on the health of the general population of the city is being assessed by dividing the city up into a number of separate districts during differing degrees of air pollution. Mortality data occurring each day in each district are obtained from the city health department, and morbidity is measured by reference to "sickness incapacity cards" prepared by the local office of the Ministry of National Insurance in respect of persons claiming sickness benefit payments.

(2) The effect of air pollution on a group of 100 chronic bronchitis patients was followed in 1956–57 by means of diary entries completed daily in which each patient recorded whether, so far as his chest was concerned, he felt in his usual health, better, or worse than usual, for the time of year.

(3) The effect of air pollution on young children is being ascertained by the long-term followup study on some 700 small children who had entered the first grade of school in the city during the year 1956. The children are grouped according to whether they live in areas of heavy industry, working-class residential areas, or new housing estates in the suburbs. The teachers in each school keep a record of each child's absence and the reason for the absence. These data are being compared with indices of air pollution, domestic overcrowding, and population density. The results of these surveys have not yet been reported and are awaited with great interest.

(c) Another survey[12] of considerable interest which was started in 1957 is one conducted by the College of General Practitioners, many of whose members are interested in research applied to general practice. About 100 general practitioners have been selected in different areas of the country which have air-pollution levels ranging from relatively clean country air to heavily polluted air in industrial cities. Each doctor is following a number of his patients throughout the year by means of clinical records and by objective tests of lung function using the newly developed Wright Peak Flow Meter. The reports

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[9] Waller, R. C., and Lawther, P. J. (1955): Some observations on London fog. Brit. Med. J. 2, 1356.

[10] Waller, R. E., and Lawther, P. J. (1957): Further observations on London fog. Brit. Med. J. 2, 1473.

[11] Pemberton, J. (1958): Personal communication.

[12] Reid, D. D., and Fairbairn, A. S. (1958): Personal communication.

from individual doctors are being collected and analyzed, but results have not yet been published.

Extrapolation of the Problem to the United States

It is exceedingly difficult to compare the effects of air pollution on the health of the British people with the same problem as it exists in the United States of America.

First, there are great differences between the nature and concentrations of air pollutants in each of these two countries. For example, in 1952, about 30 percent of the energy derived from mineral fuels and waterpower in the United States of America came from coal and over 60 percent from crude petroleum and natural gas. In Britain, 95 percent of energy was derived from coal, a large proportion of which was soft coal burned in domestic open fires which emit much smoke and gaseous acid. Air pollution levels in a typical American city, such as Cincinnati, are only one-tenth of those experienced in London.

Secondly, there are great differences in housing conditions and social customs between the two countries, and these must influence the incidence of specific diseases.

Third, there is no good evidence to show whether the diagnosis of chronic bronchitis is being based on the same diagnostic criteria in the two countries.[13] It may be that this disease is over-reported in Britain and under-reported in the United States of America.

Within the United States of America, there seems to be no clear pattern of States having a high incidence of chronic bronchitis.[14] For example, mortality from bronchitis in people over 65 years of age is higher than the national average in the case of Maine, Vermont, Pennsylvania, Virginia, Kentucky, Kansas, and Idaho. For children under 5 years, the highest bronchitis mortality is found in West Virginia, North Carolina, Indiana, Texas, Colorado, and North Dakota. The geographic distribution and degree of urbanization of these States appears to bear little relationship to this disease pattern.

If the death rates from bronchitis are compared between city and country areas in Britain it is found that the incidence of the disease is twice as high in cities as in rural areas, both for males and females. A similar comparison for the United States of America shows that deaths in cities from chronic bronchitis are only 12 percent higher for males (and insignificantly different for females) than the corresponding rates for rural areas.

On the other hand, it has been demonstrated[15] that patients living in a typical American industrial city, suffering from chronic bronchitis as diagnosed by British criteria, and who are followed from day to day by survey techniques similar to those used in the London surveys, do show a worsening of symptoms with increases in air pollution.

So then, the problem of the effect of air pollution on health in the United States still requires extensive investigation. But I am sure that this will be successful because in this country you have tremendous enthusiasm, tremendous resources, and good leadership for this type of research.

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[13] Heimann, H. (1958): Personal communication.

[14] Manos, N. (1958): Personal communication.

[15] Phair, J. J., Carey, G. C. R., Shephard, R. J. and Thomson, M. L. (1958): Some factors in the design, organization, and implementation of an air hygiene survey. Int. J. Air Poll. 1, 18.

Exposure to Low Concentrations of Air Pollution (4)—Discussion of Dr. Carey's Presentation

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Dr. Carey has given a balanced and accurate statement of the problem in England, so I will direct my comments to just a few of the points which he made.

Although the chronic respiratory illness which is known in England as chronic bronchitis has undoubtedly been present for centuries in Britain it has attracted increasing attention in recent years. It is classed as an infectious disease, and it certainly has an infectious element. Nevertheless, it shows no signs of being controlled by the powerful antibiotic drugs which have been available in recent years and which have brought many infectious diseases under control. Instead, as Dr. Carey indicated, chronic bronchitis probably has become, economically, the most serious disease in Britain. Environmental factors such as air pollution are presumably of critical importance and the disease therefore should be preventable. There is little evidence, however, that prevention has even started, although the "smokeless" areas, created as a result of the British Clean Air Act, may lead to improvement.

A complicating factor in the prevalence of this respiratory illness is the increasing fraction of the population in the older age groups, since chronic bronchitis is primarily a disease of the decades past 45 years of age. This is not to say that the early stages of the disease do not occur at an age much younger in life. What I intend to indicate by this statement is that the man over 45 is much more likely to have a chest cold which hangs on. He is likely to have the symptoms persist throughout the year and to become incapacitated.

Another cause of the current interest in chronic bronchitis was the recent series of episodes in London which resulted in excessive mortality for this group. It is true that the smog episodes in London caused increased death rates at all ages, and for almost all causes of death. The death rates in the younger age groups were increased by a factor of two or three. The specific causes of death were increased in every instance with the exception of suicide. However, one may get a false impression from these changes in death rates, for the bulk of deaths were actually among those who suffered from long-standing severe respiratory diseases or combined diseases of the heart and lungs.

It is not my intention to minimize the lethal action of the smog in these deaths, but I think it needs to be said that the smog was an accessory and not a self-sufficient cause of death. One of the exceptions to this may be the deaths of some of the prize livestock at the Smithfield Fair, which Dr. Ashe described in his presentation.

Dr. Carey and others have called attention to the contrast in prevalence between areas which are mostly rural and other areas which are highly industrialized. Death rates are about twice as high in the urban areas, and this is taken as evidence that air pollution may cause the disease. It is more striking, in my opinion, that even the rural prevalence rates are so much higher than those of the United States. If the urban areas have 40 times as much chronic bronchitis as we have in the United States, the rural areas have approximately 20 times as much as we do. One must conclude that even country air in England is dirty, or that other factors are very important in the etiology of this disease.

Dr. Carey has mentioned some of the other factors, such as cigarette smoking, which many of us like to call "personal air pollution," cross-infection in crowded households, inadequate housing, occupation, and so on. Even if one has to postulate multiple factors in the causation of this respiratory disease, there is no doubt that air pollution is an aggravating factor and one which can precipitate the final illness.

We are greatly indebted to the British for pioneering in the epidemiologic study of chronic respiratory illness. The problems of history taking, the assessment of the disease, and sampling of the population are most complex, and we admire them for their progress in this field. Modifications of their methods are now being used in this country in community and industrial surveys and we ultimately will have a truer picture of the prevalence of respiratory disease in the two countries.

My final point may be a digression, since I did not clear it with the committee that planned the meeting. However, I think that it is important. One might ask how British problems are relevant to air pollution problems in this country, and Dr. Carey has indicated that this is a difficult question to answer, and has given a number of answers. I would like to add another.

Air pollution, as he has said, is much greater in Great Britain than here and comes basically from the combustion of soft coal. Their problems will change as they convert to smokeless fuels, and optimists say that the pollution problem may disappear as nuclear powerplants replace conventional sources of power. The futility of this hope was demonstrated in England a year ago when an accident in the plutonium plant at Windscale threatened to produce an atomic disaster. The air in northwest England was contaminated with enough radioactive iodine to render 200,000 square miles of dairy country unsafe for milk production for several weeks, with serious economic loss, although no apparent damage to human beings.

Our air-pollution problems now may be different from Britain's, but in the future, in the nuclear age, they may become similar as we increase the level of radioactive pollutants, not only in the atmosphere of our industrial cities but also in the air over the country as a whole.

How Air Pollution Has Its Effects on Health (1)—The Irritant Action of Air Pollutants

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In our preceding discussion we have revolved around this general topic. I will try to put some things together which will perhaps serve the useful purpose of re-defining.

In introducing my topic I would like to give a working classification of the various health effects from air pollutants so that we can see how irritants fit into the broad picture. Excluding infectious agents, most of the health consequences of air contaminants can be put under one of four headings: (1) Allergenic effects, for example, hay fever. (2) Carcinogenic effects; these are discussed in another part of this program. (3) Systemic and specific disease response to a particular toxic agent—lead poisoning might be an example of this. (4) General response to non-specific irritants. It is the last of these that will receive my chief attention.

The justification for treating a rather diverse group of substances together stems from the fact that these materials all have in common rather similar tissue reactions. These irritant reactions are local and are observed at the point of contact. Of the exposed surfaces of the body—the skin, the eye, and the respiratory tract—the skin has not seemed to have been very important in relation to air pollutants. On the other hand, as we all know, eye irritation forms the basis for perhaps the largest body of complaints and has been experienced in many American cities by many persons. There are sound reasons for examining in some detail the health implications of materials of this kind. In two areas there seems little doubt as to their importance. These are for eye irritation and as contributors to respiratory difficulty in such major air-pollution disasters as Donora in 1948 and London in 1952. Still uncertain is the relationship to general health impairment of these irritant materials in the more moderate concentrations found in our larger cities. I will limit my discussion largely to this latter problem.

Of the materials classified as irritants, there appears to be often only the common factor of ready reactivity with tissues. The biochemical reactions involved in the irritant effect may be of differing kinds. They may be direct and essentially corrosive in nature, as for example, sulfuric acid. Aldehydes presumably react with cellular proteins. Ozone is a strong oxidant. Others have as their primary action interference with some of the intracellular enzyme systems. In each case, we are dealing with a direct and damaging local chemical action on the cell. In most instances this direct cellular action is immediate or at least rapid. Changes secondary to the direct effect can, however, in some instances, require hours or perhaps months for full development. The materials found in general community air which merit inclusion in the category of irritants as here defined include such materials as sulfur dioxide, sulfuric acid, and acid sulfates, the oxidant, ozone, such materials as the nitro-olefins, recently identified and shown to be strong eye and pulmonary irritants, and a number of unidentified organic free radicals, aldehydes, and higher oxidation products of hydrocarbons.

Both the nature and the extent of the biological response are modified by the relationship between the physical and chemical properties of the irritants and the structure and responsivity of the lung. For these reasons it will be necessary to go into these factors.

The respiratory tract can be considered to be made up of the conducting airways from the nose through the pharynx and trachea and into the bronchi. These, after many successive branchings, lead into small terminal sacs, estimated to be some 50 million in number, called alveoli. It is in these tiny units that the end purpose of respiration is accomplished, the exchange of oxygen and carbon dioxide. With progressive branching of the respiratory tree, the diameter of the conducting airways decreases, reaching a final diameter of less than a millimeter. The exposed surface area increases enormously; the analogy often given is that the surface area of the alveoli is equivalent to that of a tennis court. The tissues making up these two major parts of the system, the conducting airways and the alveoli or deep lungs, are quite different in character. The conducting airways have muscular tissue in them and can constrict; bronchial constriction, for example, is the source of the respiratory distress in asthma. The conducting airways are lined with a relatively tough layer of cells which bear cilia or small microscopic fingers which sweep inhaled foreign substances out of the lungs with a whip-like motion. The bronchial lining also contains glands which secrete mucus. The deeper parts of the lungs where gas exchange occurs do not have this protective layer of epithelium and in fact only a single very thin layer of cells lies between the very extensive bed of capillary blood vessels and the air spaces. One can readily see therefore that chemical irritants might well produce different consequences, depending on whether the irritant action occurs in the upper respiratory system, or in the deeper part, or in both. When a sufficient concentration of iritants contacts the upper airways coughing and respiratory distress shortly result. Other effects on the lining tissues of the bronchi include interference with the action of the cilia, the lung cleansing system, or change in the rate of secretion of mucus. Damage to the cilia and change in their rate of motion have been shown to result from exposure to sulfur dioxide and synthetic smog. Gases of high solubility may not penetrate beyond the conducting airways and so effects of the kind just described are all that might be seen.

However, when irritants succeed in passing beyond the bronchi and enter the alveoli, the consequences of irritant action are different. Here the primary immediate effects appear to be on cell permeability, or what may be called the "leakage rate." Generally, the effect is to lead to the passage of fluid into the alveolar spaces from the bloodstream. There also may be a change in the caliber of the capillary blood vessels of the lung in contact with this space. The entry of fluid into the air exchange units increases the distance through which oxygen and carbon dioxide must diffuse, and so impairs their exchange. There also is a reduction in the space available for gas in the lungs, and in extreme cases, whole sections of the lung may be thrown out of effective use by being literally drowned with the fluid. It can be readily seen that these irritant gases in the deep lungs would make respiration more difficult and would put increased demands on the heart. It is through mechanisms such as these that irritant gases in gas warfare or intense accidental exposure cause severe symptoms or even death. The movement of fluid into the air spaces often requires time to develop into a serious threat; accordingly there may be a delay of hours or even several days before the full effects become manifest.

Now, clearly the irritant gas or particle must reach these deep tissues for the described consequences to develop. Since the rather efficient scrubbing action of the upper airways may prevent highly soluble gases from reaching the deep lung, it is the group of irritant gases of moderate and low solubility that is of particular importance in producing irritation of the deep lungs. However, there is some evidence that the simultaneous presence of particles may aid in the transport of the more soluble gases into the deep lungs. This will be mentioned again a little later.

The effects of irritant materials so far discussed do not necessarily represent permanent irreparable damage. Function has been interfered with but structure has not yet been irreversibly altered. Accordingly, with a single nonfatal exposure, recovery might be complete, and with low levels of exposure the irritant consequences might not even be observable; at least we have every reason to believe this to be the case with healthy individuals. It is not, however, an unreasonable inference that a person who already has pulmonary edema or a heart already strained to the maximum would be able to tolerate less interference with the respiratory system than a healthy person. These are some of the grounds for being concerned with the effect of moderate concentrations of irritants in persons already under a disease stress. Where overt symptoms were observed, as for example in the Donora episode or in London in 1952, it was among these very groups of ill persons that the greatest difficulty occurred.

These functional effects have been readily apparent with the intense exposures occurring in the several air-pollution disasters. However, they are obviously very much less evident, and possibly even insignificant or absent, with the level of irritants present in the majority of American cities. One might look for an answer to this question to statistical studies of disease incidence. If health impairment of this sort is contributed to by the more moderate levels of contaminants, it is to be expected that their identification and measurement may be very difficult both because of their threshold nature and because similar symptoms are found in diseased individuals whether the air is polluted or not. An alternate mode of study depends on the quantitative measurements of the change in lung function induced by irritants. During this meeting you will hear a discussion of studies on man designed to measure some functional changes in the lungs resulting from irritant materials. Such effects have been demonstrated in the laboratory by Dr. Amdur who showed that resistance to air flow was increased in experimental animals by inhaled irritant materials.

As noted, the phenomena mentioned so far deal with dynamic changes in the functioning of the lungs, not structural damage. However, there is some basis for concern that continued irritation may lead to definite organic damage to the lung tissues. This has been the implication of British studies which associate high bronchitis rates with high pollution levels. There is, in addition, work done in Dr. Stokinger's laboratory which suggests that continued exposure to very low levels of ozone may produce fibrotic changes in the lungs of experimental animals. Other possible but uncertain consequences of the prolonged action of irritants might include emphysema, lowering of resistance to infection, and through interference with the lungs' excretory mechanism or otherwise, increased susceptibility to lung cancer from inhaled carcinogens.

The irritants we are concerned with may be in the form of gas, as in the case of ozone or sulfur dioxide, or may occur in the air as tiny particulates, as in the case of sulfuric acid droplets, other acid sulfates, or smog particles of oxidized hydrocarbons. Here, as with gases, there is selectivity with regard to the region in the respiratory system where contact occurs and action ensues. The larger particulates have a tendency to be screened out in the upper respiratory system, while smaller particulates have an increased likelihood of penetrating into the deeper lung bed. Since large and heavy particulates rapidly settle to the ground close to their source of emission, they are not normally an important factor with respect to health. The suspended particulates typically found widely distributed are generally in the smaller size ranges which readily enter the pulmonary systems. These particulates may be of interest either because they are themselves irritant—as for example, sulfuric acid droplets—or because they may intensify the action of an irritant gas.

For some time there has been concern for the possibility that the presence of particulates might synergistically potentiate the irritant action of gases. There are a number of reasons why this seems possible. I will mention two major possibilities. If irritant gases are dissolved in or adsorbed on particulates, such gases may be carried past the normal protective mechanism of the upper respiratory passage and brought down into the deeper and more vital parts of the lung. Another mechanism through which potentiation might arise is by the production of a more intense local tissue dose at the point where the particle lands than would occur by normal gas absorbtion due to a high local concentration of adsorbed gas around the particle. Experimental verification of potentiation in animal studies appears to have been accomplished by the work of Dr. Labelle and in other studies by Dr. Amdur. In the latter work, the presence of fine sodium chloride particles, in themselves innocuous, intensified the physiological effect of the irritant gas, sulfur dioxide, by a factor of some 30 times. Goetz has suggested that this phenomenon may be of rather general importance and has outlined some of the characteristic interrelationships of gases and of particulates which would determine whether synergism would occur or not.

We are dealing here, as in almost all other biologic effects, with dose-related phenomena; that is to say, the greater the dose or insult the more intense the response. Over past years a widely accepted series of guides for safe concentration of toxic materials in industrial workplaces has been developed. These are generally known as maximum acceptable concentrations, or MAC's. They represent an attempt to define levels which experience or experiment presumably has shown to be tolerated by healthy workers without harm. I need not labor the irrelevance of standards established for these special circumstances to the general air pollution situation where individuals are exposed for a lifetime and perhaps around the clock, whether ill or well. It may well be that we will eventually have sufficient knowledge to set up analogous standards for air pollutants; we do not have such information now. It is worth noting that even the occasional unusually high values found in the general air of American cities are almost invariably very much below industrial hygiene MAC values used in this country. Parenthetically, it may be pointed out that this contrast is particularly great with respect to the problem of systemic disease from trace metals found as general air pollutants. We have no evidence at this time that systemic disease from trace quantities of toxins are of significant health concern. It may be, of course, that obscure disease relationships exist of which we know nothing at the present time.

In our present problem we are confronted with one of the most difficult tasks biologists are asked to deal with, that is, extrapolation from doses producing readily measurable responses to lower and threshold levels. The quantitative relationship between dose and effect is practically never a simple linear one. In fact, with most irritant materials there clearly appears to be a "no effect" level; that is to say, very low rates of dosage can be dealt with by the body's protective mechanisms without damage. From this standpoint spiking concentrations of relatively brief high levels may be more damaging than the same amount of materials inhaled uniformly over a long period of time. Our uncertainty as to the presence of threshold, and if so its quantitative level, is one of the additional and vexing uncertainties in this problem.

We have accordingly grounds for suspicion that respiratory irritants may be a significant health concern. Even for the higher concentrations found occasionally in our urban areas this is still based largely on inference from the points made above. It is clear, therefore, that an effort consonant in extent with these suspicions is required to clarify the problem.

How Air Pollution Has Its Effects on Health (2)—Air Pollution and Lung Function Changes

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It is the function of the lung to extract oxygen from and return carbon dioxide to that most impalpable of substances, air, with whose pollution by extraneous matter we are here concerned. In order to perform this function, a parcel of air is transported from its usual external place into the chest. Here, in the lung, the incoming tide of air yields up its oxygen to the pulsing blood, from which it is separated by the thinnest of membranes, dividing the capillary blood vessels of the lung from the minute air sacs which are called alveoli.

The ebb tide of each breath carries out its small burden of carbon dioxide and its deficit of oxygen to the parent atmosphere. Each day about 30 pounds of air participates in this tidal flow, compared with less than 4 pounds of food and 5 pounds of water.

Let us consider the nature and extent of interference with this process which occurs when the air we breathe contains any foreign substance which is irritating. We know how the lung reacts to the inhalation of silica dust, which may produce silicosis; how it reacts to the inhalation of tubercle bacilli, which may produce tuberculosis; and how it reacts to many other toxic substances. But toxic substances in toxic amounts have not been found in community air pollution, even during the disasters of which you have heard.

What we do find in community air pollution are substances in amounts sufficient to cause widespread irritation of the eyes, of the nose, and of the throat. We shall see what such substances can do to the vital functions of the lung. First, consider what these functions are.

The lung and airway provide a highly effective air-conditioning system which adds water vapor and heat to the air, so that when air reaches the alveoli it is at the same temperature as the blood and saturated with water vapor.

The conducting airway is lined with a layer of mucus which is continually moved toward the throat by the beating of tiny whiplike cellular projections called cilia. The larger particles or droplets of irritating air pollutants are caught in this mucus and by this device the lung has a measure of protection from them.

The tidal flow of air occurs by reason of the rhythmic contraction of the diaphragm and other muscles, supplemented by the elastic recoil of the expanded lung. With muscular weakness, as in polio, or with loss of elasticity as occurs in a disease called emphysema of the lungs, there will be less effective gas flow. The cause of emphysema is not known, but it is a relatively common condition in the cities of Great Britain which are afflicted with air pollution. Some think that repeated inhalation of irritating smoke and fumes causes the disease.[1]

As the airways conducting gas to the alveoli divide, they get smaller; the smallest division, called a bronchiole, has a diameter of 0.016 inch. At this level there is no mucous layer to protect the cells which form its wall, and they may be affected by irritating substances in the air, all of which must pass through the bronchioles before reaching the level at which gas exchange occurs.

We are not certain whether irritants in the air cause the cells lining the bronchiole to swell up, cause the glands to increase their secretion, or produce contraction of the muscle cells which are wrapped around the bronchiole; but laboratory studies suggest that all of these effects are possible. Any one of these three reactions would have the effect of decreasing the caliber of the bronchiole. The physicists who study air flow tell us that the resistance to flow is inversely proportional to the fourth power of the diameter of the conducting tube. For example, a caliber decrease of only one-fifth will double the resistance to airflow. Because of this we have focused our attention on the resistance to airflow within the lung as one means of estimating the effects of irritating air pollution.

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[1] Fletcher, C. M., "Chronic Disabling Respiratory Disease." California Medicine. 88, 1, January 1958.

The normal person can greatly increase the amount of air subjected to gas exchange in the lung. The work or effort needed to produce this increase is kept to a minimum by the low resistance to airflow through the bronchi or bronchioles. An increase in this resistance means that the reserves of lung capacity are available to normal healthy persons only at the expense of increased work. To persons ill with asthma, emphysema, or heart trouble, with little or no reserves, this added work may tip the scales in an unfavorable direction.

A number of experimental, clinical, and field studies have been done on the effect of air pollution on lung airway resistance. Dr. Mary Amdur at Harvard[2] has developed a method for measuring the effect of gases on the airway resistance of guinea pigs, using principally sulfur dioxide. One startling result of her work is the finding that the presence of minute droplets of common salt solution in the air greatly increases the sensitivity of the guinea pig to sulfur dioxide. In fact, in the presence of salt mist, the concentration of SO_2 at which the guinea pig resistance increases is very near that which occurs during the air pollution episodes in which SO_2 is a major pollutant.

Experimental studies on the effect of air pollutants on the airway resistance of man are not quite so far advanced. The reason for this is that to measure resistance to flow between two points, one needs to know the pressure gradient between those two points and the flow occurring at that pressure. Measurement of flow is comparatively simple. Measuring the pressure within the lung has been the problem; in the guinea pig one may simply place a small tube into the chest. Dr. Arthur DuBois[3] has devised a method for measuring pressure in the human lung which merely requires that the subject be seated in a box like a telephone booth which is sealed for a minute or so while measurements are made. From a simple physical equation relating pressure and volume one can obtain the lung pressure. With this box, which is called a body plethysmograph, Dr. DuBois and Dr. Dautrebande have shown that a fine dust of charcoal powder, or aluminum, or a mist of india ink when inhaled, produces an increase of two to three times in the resistance to airflow. Since these are substances not known to be irritating and the subjects were not aware of any resistance to breathing, it is likely that this method will prove to be quite a sensitive one for laboratory studies.

Two other laboratory studies used less direct methods, based on the following principles. It is known that as the pressure applied to make air flow out of the lung increases, the flow increases by less and less until finally, increasing the pressure no longer increases the flow. If one then has a subject blow out his air as hard as he can from a condition in which he has as much air in his lungs as possible, then one may measure the maximum rate of airflow and ignore the effect of pressure, on the assumption that rather wide differences in pressure do not influence the maximal flow rate. The maximal flow rate then becomes an indirect way of estimating the flow resistance. The advantage of this is that it can be done very quickly and with very simple equipment;[4] observation of a drop in maximal flow rate is then assumed to indicate a rise in flow resistance.

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[2] Amdur, M. O., "The Influence of Aerosols Upon the Respiratory Response of Guinea Pigs to Sulfur Dioxide." Industrial Hygiene Quarterly, p. 149, June 1957.

[3] DuBois, A. B., Botelho, S. Y., and Comroe, J., Journal of Clinical Investigation 35, 327, 1956.

In England, Dr. Sim[5] studied the effect of sulfuric acid mists and of sulfur dioxide in human volunteers. He found no consistent change in the conventional pulmonary function tests, but did observe an increase in air flow resistance.

Finally, there have been a number of studies on persons in California who happen to be exposed to the air pollution which may occur there. In each study somewhat different methods were used. Dr. Hurley Motley has collected data on patients with fairly severe emphysema of the lungs while they were breathing the polluted air of Los Angeles. He then put these patients in a room with filters so that the smog was taken out of the air, and repeated the tests. Dr. Motley found that a number of these patients did improve their lung function.[6]

Dr. Roger Wilson in San Francisco[7] has been studying the same sort of patient at two weekly intervals and performing vital capacity tests and timed vital capacity tests, the latter being a sort of averaged maximal expiratory flow test.

Dr. Charles Schoettlin,[8] on assignment by the Public Health Service to our Department, has been studying a group of men at the Veterans Administration Center in Los Angeles this summer and fall. His subjects are equally divided between those with chronic "emphysema-like" disease of the lung and those without such disease. The men in these groups are matched for age and smoking history. Dr. Schoettlin has been measuring the vital capacity, the timed vital capacity, and the maximal flow rate as well as making clinical evaluation of his subjects. Analysis of these two later studies is not as yet complete.

Asthmatic subjects are having pulmonary function tests in the Nashville community study carried on by the U.S. Public Health Service.

There certainly may be interference with gas transport if irritating substances produce edema and thickening of the wall of the alveoli. Dr Goeffrey Carey[9] and his colleagues have worked out methods for studying lung function and have observed some impairment of the diffusion capacity of the lung during air-pollution episodes in Cincinnati.

In the preceding discussion we have spoken principally about the direct consequences of irritants on the caliber of the air passages or the thickness of the membrane through which gas must be exchanged. There are indirect mechanisms also. You are all familiar with the fact that persons with allergies may have serious interference with breathing on exposure to minute amounts of substances to which they are sensitive. Since it is known that such reactions, the commonest of which is asthma, may occur not only on inhaling such substances, but also if they are injected or ingested, these asthmatic reactions seem to depend on some reflex or indirect mechanism. It is reasonable to assume that a reflex asthmatic reaction may also occur with inhaled irritants but it is difficult to separate the direct effect of irritants from reflex effects.

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[4] Goldsmith, J. R., "A Simple Test of Maximal Expiratory Flow for Detecting Ventilatory Obstruction." Am. Rev. Tuberc. 78, 180, 1958.

[5] Sim, V. M., and Pattle, R. E., "Effect of Possible Smog Irritants on Human Subjects." J.A.M.A. *165*, 1908, 1957 (Dec. 14).

[6] Motley, H.—Personal Communication.

[7] Wilson, R. H. L.—Personal Communication.

[8] Schoettlin, C.—Personal Communication.

[9] Carey, G. C. R., in Proceedings of Second Air Pollution Research Planning Seminar, February 3-7, 1958, U.S. Public Health Service. (p. 79).

You have heard that among the victims of air-pollution episodes are many patients with chronic heart disease, and Dr. Carey has indicated that persons suffering from chronic bronchitis may overload the heart because of this disease. Indeed, there is a well recognized type of heart disease often associated with emphysema of the lungs; presumably this is related to the increased resistance to bloodflow through the lung due to scarring and destruction of many of the small blood vessels surrounding the alveoli or air sacs. We believe that there is also an acute effect on the circulatory system when irritants are inhaled. The flushing of one's face upon repeated coughs is convincing evidence of this. Quantitative studies of this effect are still needed, and here also it is possible that both a direct and a reflex mechanism are at work. To study in greater detail the circulatory effects of respiratory irritation is a job for the immediate future.

The direct effect of inhaled irritant substances has been suggested by the investigations of the serious air-pollution episodes in the past. Two such mechanisms have been discussed, increase in the resistance to airflow by reaction of the cells lining the airway, and thickening or swelling of the membrane of the alveoli or air sacs of the lung through which gases must be transferred. Reflex pathways may also constitute a method by which the lung alters its function when exposed to irritants.

The heart and circulation are known to be affected acutely by irritants in the air. It is also well-known that chronic lung diseases such as emphysema are associated with their particular type of heart disease. Quantative studies of these facts are going forward, and we look forward with some confidence to fruitful research in these areas.

How Air Pollution Has Its Effects on Health (3)—Discussion of Dr. Goldsmith's Presentation

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I shall discuss Dr. Goldsmith's paper primarily from the standpoint of a clinician who limits his practice to medical diseases of the chest and also as the representative of one of the large county medical associations where we have a very serious air-pollution problem. We have approximately 7,000 members in the Los Angeles County Medical Association and serve a population of about 5½ million people. Our association has been concerned about the health effects of air pollution for some time. About a year ago we sent out a questionnaire to all the members of the association and received about 1,500 replies.[1] From those replies there is no doubt that the practicing physicians in Los Angeles County have observed that air pollution has an adverse effect on lung function in certain patients. For example, 52 percent of the group replying said that they knew of individuals who had left the Los Angeles area solely because of air pollution. Forty-one percent said they had advised some of their patients to leave the area.

When the data were analyzed on the basis of the replies of physicians in various specialties, it is interesting that 87 percent of the physicians who limited their practice to pulmonary disease had observed that people with chronic pulmonary disease were more apt to be adversely affected than healthy individuals. Fifty percent of the cardiologists reported that their patients were more apt to be affected than people who did not have cardiovascular disease; and 90 percent of the allergists felt that persons suffering from allergic difficulties were more likely to have symptoms than non-allergic individuals. Eighty-two percent of physicians specializing in pathology, radiology, or oncology were of the opinion that "smog was a contributory factor in cancer of the lungs and air passages." Thus, there is a definite observation on the part of practicing physicians in a number of specialties, as well as those in general practice, that air pollution affects the well-being of many patients.

In our own hospital and clinical practice we see a large number of patients with emphysema and other chronic pulmonary diseases. We have been able to have complete pulmonary function studies done in the University of Southern California Cardio-Respiratory Research Laboratory. Dr. Motley has now studied over 100 patients with objective pulmonary function studies during periods of smog; and immediately thereafter, these individuals have been placed in air-filtered rooms where an activated charcoal filter removes all traces of smog.[2]

The great majority of the patients having severe pulmonary emphysema have shown a significant reduction in their residual air after being placed in the filtered room. In other words, their emphysema gets better after they are in a smog-free atmosphere. They also usually have a significant increase in the total vital capacity, and particularly an increase in the 3-second-timed vital capacity, which is actually the usable vital capacity. A few patients have shown a significant improvement in arterial oxygen saturation, occasionally as much as a 5 percent increase, after being in the filtered air. Dr. Motley has not found significant differences in the healthy individuals that are studied by this method. The more severe cases of emphysema show the greatest improvement after being placed in smog-free air.

It is noteworthy that the time factor is very important. If patients are exposed to smog for only 12 hours and then are placed in an air-filtered room, we do not see as great differences as when the individual has been exposed to smog for 2 or 3 days. In these patients, the effect of smog seems to build up with prolonged exposure to air pollution.

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[1] "Summarization of Responses to Smog Questionnaires Sent to Members of the Los Angeles County Medical Association"—February 1957. Air Pollution Control District—County of Los Angeles Research Division.

[2] Personal Communications—Hurley L. Motley, Ph. D., M.D., Director Cardio-Respiratory Laboratory, University of Southern California.

Furthermore, we have found in some patients that after reexposure to smog, the improvement is lost. Also, if patients are put in a filtered room for only 12 hours, we get very little improvement; they must stay in for at least 48 hours in order to remove the adverse physiological effects of breathing polluted air.

These experimental data on humans are consistent with the experiences in the smog disasters described here earlier today. In most instances the effect of smog builds up as the time of exposure is prolonged. In the London disaster there were 4,000 excess deaths in the first week and something like 8,000 in the second week.[3] Thus we have objective data, which, while not conclusive, are certainly suggestive that smog as it occurs in the Los Angeles basin does affect lung function in people who already have chronic pulmonary disease, and particularly emphysema.

It has also been our observation that those patients who have bronchial asthma and emphysema or chronic bronchitis associated with bronchospasm and emphysema, show greater susceptibility to the effects of smog. This group of patients have been compared with those that were exposed to cigarette smoke. The tobacco experiment was initially set up by having the individual smoke two cigarettes immediately between the original study and the followup study. Very little difference between the two studies was noted. Consequently it was necessary to use a smoking device whereby the individual would get some smoke with each breath so as to get good distribution of the smoke throughout the respiratory tract. This experiment showed significant differences in arterial oxygen saturation, pulmonary compliance, and the degree of emphysema before and after smoking.[4]

Of course, this is an acute exposure of habitual smokers. It is not possible to take an individual who has never smoked and have him use this smoking device, because you get the toxic effects of nicotine; the patient will become nauseated and be unable to complete the experiment. However, I should like to emphasize that the magnitude of changes in individuals exposed to natural smog has been considerably greater than in those exposed to tobacco smoke.

Naturally, these data are not conclusive; they are only suggestive. However, the pulmonary function measurements have been carefully carried out by an experienced physiologic team. We believe that they confirm the clinical judgment of the practicing physicians that smog does alter lung function in patients already having chronic pulmonary disease and furthermore, they are in conformity with what has been observed in the "smog disasters."

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[3] The Harben Lectures, 1956. "Air Pollution and the Public Health" by Prof. Philip Drinker, B.S., Chem. E., D. Sc., LL.D. Journal of The Royal Institute of Public Health and Hygiene, July, August, and September issues, 1957. Pages 228–229.

[4] "Cigarette Smoke—Its Effect on Pulmonary Function Measurements" by Hurley L. Motley, M.D., and William J. Kuzman, M.D., Los Angeles. California Medicine, 88: 211–220, March 1958.

Air Pollution and Cancer (1)—The Relation of Air Pollution and Cancer

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As an introductory background, I should like to make an analogy between communicable disease and cancer to illustrate the problems associated with the question at hand, what is the relation of atmospheric pollution and cancer?

The generic terms of communicable disease and cancer resemble each other in that each includes a number of different disease entities and both have multiple causes. The factors associated with the cause of the various communicable diseases have been identified to a considerable extent. Such is not the case, however, with cancer in general, and even less for the specific types of cancer. This is mentioned to bring into focus the comparative extent of our knowledge relative to the specific causes of cancer and to suggest that our status of knowledge of cancer may be similar to the era, years ago, when the broad term of communicable diseases was first divided and redivided into the specific diseases as the etiological agents and factors were identified, one by one. Just as it was difficult then to foresee and believe the existence of certain interrelationships in the identification of organisms and the harmonic balance of agent, host, and environment, so there may now seem an even more difficult and complex area of resolution in the relation of atmospheric pollution and cancer. In the one instance a short latent period occurs between exposure and the development of the disease in terms of days or weeks for communicable disease. This made easier and more readily possible the recognition of the association of the factors involved and the eventual identification of the bacterial agents. Such is not the case in cancer, with a latent period believed to be of many years duration. The development of factors of association, in subsequent time periods of 20 or 30 years, makes the resolution of the question by epidemiological means quite difficult and formidable.

The etiological spectrum of comunicable diseases relates to micro-organisms and the chemical composition of micro-organisms may be altered by exogenous chemicals or by physical environmental factors. Although viruses have been identified as causative agents for some cancers, in the field of atmospheric pollution we are referring to the chemical spectrum which may cause cancer. In general, principles of transmission of disease are similar between micro-organisms or chemicals by inhalation, ingestion, absorption, and direct contact.

The dosage and exposure requirements differ greatly, however. Perhaps the greatest difference between micro-organisms and exogenous chemicals is that one can reproduce itself and, therefore, creates a different problem of observation from that of exogenous chemicals.

The virulence of an organism and the toxicity of certain chemicals play comparative roles; yet, in the case of exogenous chemicals the concentration and the duration of exposure are of primary importance. In the case of communicable disease the type of disease can be related to a specific organism, whereas the types of cancer are not, in general, identifiable by a single specific cause. Further, the cancer of a specific site such as the lung may be due to a number of different causes, yet microscopically the lung tumor may not appear to be different.

Three etiological factors are currently commanding attention in relation to the rising trend of lung cancer. They are tobacco smoking, occupational exposure to carcinogens, and atmospheric pollution. Opinions as to the degree of importance to be attached to each of these factors vary among members of the medical profession and research workers concerned. The variations of the so-called normal general population for specific causes of death, by age, sex, color, country of birth, socio-economic status and geographical area have been established. However, an appreciation of these variations is essential in the evaluation of any epidemiological data and, in particular, for studies of cancer as they relate to air pollution.

Cancer Trend—Age and Sex Comparisons

Dorn's comprehensive study of cancer mortality trends has shown that the more important forms of cancer for which the death rate is still increasing are leukemia, Hodgkins Disease, cancer of the lung, ovary, pancreas, bladder, and kidney. Cancer of the lung has shown the greatest increase among white males, which cannot be attributed solely to changes in procedures for coding and classifying death or improvements in diagnosis and more complete case finding.[1] Table V shows the change in rates and relative changes from 1914 to 1954 for white males and females. You will see in this table that the white male rate in 1914 was 0.75 and rose to 26.57 in 1954. Comparatively, the white females showed a change from 0.64 in 1914 to 4.45 in 1954.

In a further analysis, Dorn compared cohort mortality rates for cancer of the lung for white males and females in the United States and made the following observations: "These data suggest . . . that males either are exposed to different carcinogenic agents than are females or else are more heavily exposed to the same agents, and that the amount of exposure for males has increased sharply since 1900.[1]

Urban, Rural, Nativity, and Color Comparisons

Since it has been established that among residents in urban areas there is a marked excess of lung cancer over those in rural areas, questions have been raised as to why this is so. The availability of medical care and improved diagnosis probably does not account for all of this increase in the urban area.

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[1] Cancer Mortality Trends in the United States of America. Harold F. Dorn, Ph. D., Cancer, vol. 3—Butterworth and Company, London. 1958.

Studies of cancer mortality according to size of community have shown that for certain cancer sites, including cancer of the lung, there is an increase in rate with an increase in size of the city.[2] [3] Although "practically no differences in smoking patterns according to size of urban community was noted in the United States,"[4] marked differences in rates have been observed for lung cancer among cities of the same and greater populations in the same State as well as in other geographical areas. For the United States, cancer of respiratory system—lung, bronchus, and larynx—the males show a marked excess for metropolitan areas in contrast to nonmetropolitan, in a ratio of 1.71, whereas the females in a similar comparison show only a minor difference, with a ratio of 1.16.[5]

TABLE V.—*Cancer of the lung: age-adjusted death rates per 100,000 population, white males and females, United States of America, 1914–54*

Year	White males		White females	
	Rate	Relative change 1914=100	Rate	Relative change 1914=100
1914	0. 75	100	0. 64	100
1930–32	4. 22	563	2. 34	366
1939–41	9. 96	1, 328	3. 54	553
1949–51	20. 30	2, 707	4. 30	672
1954	26. 57	3, 543	4. 45	695

Total population, continental United States on July 1, 1949, used as standard.

Cancer Mortality Trends in the United States of America by Harold F. Dorn, Ph. D.

The foreign born also have been found to have a higher mortality rate for lung cancer than the native white and nonwhite, in the State of Ohio.[6] This is visualized in figure 3.

As you can see in figure 3, the foreign born have a much higher rate for lung cancer than either the native white or the nonwhite in the urban areas, and the foreign born excess for lung cancer also carries over into the rural areas. You will notice that the urban-rural comparison for the native whites shows an urban rate twice as high as the rural rate.

It would appear that there may be some additional factors contributing to the lung cancer mortality of the foreign born. This observation relative to the foreign born raises the basic question: are

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[2] Distribution of Cancer Mortality in Ohio. Thomas F. Mancuso, M.D., Elizabeth M. Macfarlane, John D. Porterfield, M.D. APHA, vol. 45, pp. 58–70, January 1955.

[3] Some Considerations in the Interpretation of Air Pollution Health Effects Data. Richard A. Prindle, M.D. Presentation at Air Pollution Control Associa-

[4] Tobacco Smoking Patterns in the United States, U.S. Department of Health, Education, and Welfare. Public Health Monograph No. 45. William Haenszel, Michael B. Shimkin, and Herman P. Miller. May 1956.

[5] The Extent of Cancer Illness in the United States. U.S. Department of Health, Education, and Welfare. Public Health Service Bulletin No. 547, 1958.

[6] Cancer Mortality Among Native White, Foreign Born White, and Nonwhite Male Residents of Ohio. Thomas F. Mancuso and Elizabeth J. Coulter, Journal of National Cancer Institute. Vol. 20, No. 1—January 1958.

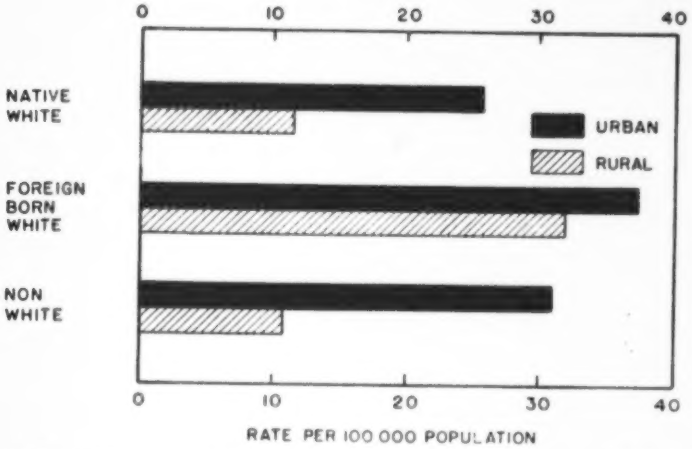

FIGURE 3.—Average annual age-adjusted death rate due to cancer of the lung among native white, foreign born white, and nonwhite males, 25-64 years of age, residing in urban and rural areas of Ohio, 1947-51.

the nativity differences in cancer mortality due to factors associated with the place where an individual is born or the place to which he migrates? Eastcott found that immigrants to New Zealand from the United Kingdom have a higher incidence of lung cancer than New Zealand-born persons of the same stock. The difference was greater for those who were aged 30 or more when they came to New Zealand. The observation was the same for women as for men. The risk was found to be 75 percent higher for United Kingdom immigrants who were 30 years of age or more on entering New Zealand. The conclusion derived from this study was that immigrants from Great Britain to New Zealand are affected by their former environment and that this effect was related to the length of exposure in that environment, the evidence pointing to factors of urbanization such as air pollution.[7]

Figure 3 also shows that in one State, in a comparison of native white and nonwhite in urban areas, where availability of medical care is less likely to influence the rates in favor of the nonwhites, an urban excess was found for the nonwhites, based upon mortality data for lung cancer. This approximation of the native white and nonwhite lung cancer mortality rates occurs when the influence of the foreign born is removed from the total white lung cancer rate. The nonwhite rate for lung cancer is also higher than the total white male rate for this State.[8] This is of some interest in view of the observation that "the proportion of white male cigarette smokers who use more than one pack of cigarettes daily is almost double the proportion among the nonwhite males."[4] Similarly, the marked excess for mortality due to cancer of the esophagus in urban areas among the white males is also exceeded by the nonwhite.

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[7] The Epidemiology of Lung Cancer in New Zealand. David F. Eastcott. Lancet, January 7, 1956.

[8] Cancer Mortality by Sex, Color, and Age—Eight Metropolitan Counties of Ohio, 1950-56. Thomas F. Mancuso and Elizabeth J. Coulter. Ohio Department of Health. Unpublished Data—1958.

Socio-Economic Variations

The association between socio-economic status and causes of death has been established for many years, principally in England and Wales. In these studies, socio-economic status grouped in five social classes was related to the occupation of the deceased. These studies demonstrated the influence of general socio-environmental factors on mortality. In the United States a study of cancer incidence of 10 metropolitan areas, according to socio-economic status related to median family income of the residents, showed that only certain specific forms of cancer are associated with income and the nature of the association varied with the primary site of the tumor. Among this group, cancer of the lung and bronchus showed a consistent above-average incidence among men of low socio-economic status[9] which was consistent with findings in England and Wales. This was also true for cancer of the esophagus.

In the consideration of atmospheric pollution effects, socio-economic status by census tracts—identified by average rental and race, as well as nativity—may have some significance if one assumes that the lowest rental areas are likely to be nearest the sources of air pollution of a city. In any event, it has become increasingly apparent that further socio-economic studies are highly desirable in the epidemiological study of environmental and cultural factors associated with the causation of cancer.

Atmospheric Pollutants

The extent of air pollution and the sources of air pollution are being presented at the group "A" and group "B" sessions. I should like, however, to refer briefly to these aspects.

Atmospheric pollution varies in type and concentration in a great number of ways: by geographical area, by type of area, size of community, pattern of living and industry of a community, meteorological conditions, by seasons, by day, by hour, etc. Even within the same city, atmospheric pollution may vary significantly by census tracts. Associated with this are the problems of effects of continuous and intermittent exposures as one moves from one area to another or resides in an area with changing conditions over the years.

In the consideration of air pollution, one must also think of the probable chemical contamination of water supplies which, when added to the existing problem of industrial wastes, raises some important questions as to what chemical changes are occurring and what are their long-term toxicological effects, in terms of cancer or other disease.

Stocks and Campbell have estimated that 50 percent of the lung cancer deaths in the Liverpool area result from smoking and about 35 percent from air pollution.[10] Hammond estimated that about 31 percent of lung cancer deaths are due to air pollution.[10] These may be minimal estimates of the probable role of air pollutants in pulmonary carcinogenesis. Tebbens has shown that during the combustion of liquid, solid, and gaseous fuels, hydrocarbons are produced which may include several well known carcinogens.[11] [12] Kotin has conducted the most extensive animal cancer studies relating to air pollution and you will hear from him directly.

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[9] Variation in Cancer Incidence by Income—From Cancer Morbidity in the United States. Part II. Harold F. Dorn and Sidney J. Cutler. Public Health Service (In Press). 1958 (1959).

[10] Smoking and Health: Report of Study Group on Smoking and Health—Section on Lung Cancer. Bulletin of Cancer Progress by American Cancer Society, Inc., March–April, 1958, vol. 8, No. 2, p. 58.

Epidemiological studies have been conducted in which the interrelation of smoking, atmospheric pollution, and occupational classifications have been considered. The limitations of such studies include the inability to assess accurately the extent of the pathological effects due to occupational exposure because of the lack of long-term studies of occupational groups. It is apparent too that in retrospective or prospective studies, the lifetime occupational histories and durations of employment are required with the same precision as is applied to other variables. Similarly, in "current" surveys of smoking patterns, employment classification, and residence, it is acknowledged that there may be no direct connection to the life pattern of smoking or of the duration and changes of previous employment or residence.

Information is lacking as to how the various industrial population groups differ from each other in terms of life expectancy and causes of death patterns among cohort populations which differ primarily in the working environment. In addition, since the occupational dusts, fumes, mists, and gases that have been produced in the past 20 to 30 years in industry have not been adequately explored for their carcinogenic properties, one cannot arbitrarily say that the lung cancer rate has not been affected by occupational exposure or that it is of minor importance.

Epidemiological Aspects

The presently available biological tests and means for measuring or determining physiological or pathological changes in humans which may be due specifically to atmospheric pollutants are extremely limited. Similarly, toxicological data are lacking with respect to long-term exposure of humans and animals to low concentrations of the various chemical substances involved. The utilization of the epidemiological approach in connection with community air-pollution medical research, therefore, is of special importance in the determination of any health effects for the population exposed. This approach is concerned with the search for significant sickness or death characteristics peculiar to urban areas where there has been human exposure for many years to various types and degrees of community air pollution. It is necessary to determine whether morbidity and mortality data differ between population groups exposed and those not exposed to specific types of combinations of pollutants. These determinations become meaningful when the data are related to the years of residence for the population under study in a given area.

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[11] Hydrocarbon Synthesis in Combustion, Bernard D. Tebbens, Jerome F. Thomas, Mitsugi Makai, AMA Arch. Ind. Health. June 1956, vol. 13, pp. 567–573.

[12] Aromatic Hydrocarbon Production Related to Incomplete Combustion. Bernard D. Tebbens, Jerome F. Thomas, and Mitsugi Makai. AMA Archives of Industrial Health, November 1956. Vol. 14, pp. 413–415.

There are a number of reasons for using residence exposure years as the basic unit in epidemiological evaluations of the cumulative effects of long-term exposure to atmospheric pollutants.[13] In studying diseases having long latent periods, it should be noted that the current place of residence of population groups under study may not be the "place of exposure." This applies to the following types of current residence: death residence, place of retirement, place where special medical or surgical care is being utilized, place to which there has been significant migration because of attractive climate and/or job opportunities, and places within a city to which there have been population shifts with respect to race, nationality, and socio-economic status. These types of current residence, singly or in combination, bring about shifts in the age distribution of the population, as well as in the cause of death, thereby affecting the mortality pattern of the given locality. It is necessary not only to study the general population groups but also specific population groups (cohorts) as well, identified by location and by adequate length of residence over long periods of time (longitudinal studies).

It must be recognized, however, that we actually do not know much about the latent period of cancer and the interrelation with dosage and continuous and intermittent exposure.

In summary, in reviewing these various areas of consideration, the evidence of an "urban" factor for lung cancer distinct from smoking patterns, or questions of classification or diagnosis, appears to be secure. This excess in urban areas for lung cancer increases by size of city, when smoking patterns are held constant, and varies by geographical areas. A color difference in the urban areas of the nonwhite over the native white as well as total white males for lung cancer also occurs even though the smoking patterns of the white are much greater and finally, the native white male mortality rate for lung cancer is over 100 percent greater in urban areas than in rural areas. There is also evidence that the foreign born lung cancer rate of immigrants from England and Wales to New Zealand may be related to environmental factors such as air pollution.

On the other hand, the sex difference on an urban-rural basis would indicate that if atmospheric pollution is involved, it is not affecting both sexes equally, or that some other factors in addition to air pollution are operating to contribute to the male excess for lung cancer. Other factors associated with lung cancer are low socio-economic status and foreign birth.

In conclusion I believe that air pollution represents a highly probable and important factor in the excess of lung cancer in urban areas, acting directly and augmenting the occupational exposures of men, so that carcinogenic and co-carcinogenic, or potentiating agents of both environments may be involved.

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[13] Proposed Initial Studies of the Relationship of Community Air Pollution to Health. Thomas F. Mancuso, M.D., and J. Solon Mordell. Public Health Service Report. October 1955.

Air Pollution and Cancer (2)—Experimental Tumor Production With Air Pollutants

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The determination of possible harmful effects of air pollutants on exposed populations is one of the current critical problems in the study of diseases of environmental origin. Historically, clamor and concern have followed acute episodes in which geographic, meteorologic, and industrial factors have united to produce a marked effect on exposed populations. At present there is occurring an increasing awareness and recognition of a possible health hazard even at pollutant levels below those producing acute symptoms. Toxicological studies have thus far been essentially inadequate for the pinpointing of the agents responsible for the acute symptoms observed in disasters and during repetitive intervals of symptom-producing smogs in urban areas. New analytical and biological techniques may be necessary before adequate control of air pollution can be based on sound scientific knowledge. In addition to the acute or immediate response to air pollutants, a second area of potential danger resides in the prolonged or cumulative effect. This is especially so when pollution levels are below those that produce symptoms, so that a feeling of false security exists. The ultimate response to long-term exposure, however, may be of an irreversible type. A notable example is the carcinogenic effect, and it is with this entity that this report is primarily concerned.

Certain epidemiological facets of the increasing incidence of lung cancer suggest that the atmospheric environment may be causally associated with this observed increase. Epidemiological data serve to indicate the areas for experimental biological efforts. The physical sciences provide the facilities for duplicating the naturally occurring environment in the laboratory. With knowledge gained as a result, laboratory biological investigations can be properly formulated and implemented. While these are necessarily primarily limited to animal species, much significant information can be obtained. Animal studies can and do provide numerous advantages. The first and most obvious, of course, is avoiding the necessity of prolonged human experimentation with toxic agents. Second, the use of large numbers of animals permits the study of sequential changes in the development of an adverse response. Careful assessment of host resistance factors in overcoming these negative effects is also frequently possible. Third, protective or therapeutic measures aimed at controlling the effect of air pollutants can be quantitatively studied. Fourth, within limits, practically any state of human health, from the young and vigorous to the old and partially decompensated, can be reproduced in animals.

Factors to be considered in animal experimentation are: (1) the choice of species; (2) selection of appropriate strains where inbred strains of a given species exist; (3) concentration of the test material, with special efforts aimed at reducing the artifactitious concentration as much as possible; (4) duration of exposure; and (5) routes of administration. The ultimate goal in all of this is, of course, selection of laboratory circumstances most nearly duplicating the human experience. Despite the existence of many variables, past experience has shown a high index of meaningfulness of animal experimental data for the human species.

In relation to the carcinogenic hazards of air pollution, it is our belief that animal data are particularly pertinent. This is so for several reasons. First, in the panorama of lung cancer, all available evidence points to a dominant etiological role for exogenous agents present in our respiratory environment. These can be tested under controlled laboratory circumstances. With full knowledge that cancer rarely develops subsequent to the action of a single factor, atmospheric pollution, both epidemiologically and in the laboratory, must be regarded as one of multiple factors operating in combination to result in lung cancer. As in all instances where an association between a morbid state and environmental factors has been demonstrated, the isolation and identification of specific causative agents and determination of their mode of action have been primarily laboratory undertakings.

Accomplishments thus far in fulfillment of these functions may be listed as follows:

1. Carcinogenic aromatic polycyclic hydrocarbons have been demonstrated and quantitated in polluted atmosphere of urban communities. Compounds identified included 3,4-benzpyrene and, more recently, 3,4-benzfluoranthrene. These agents have been used to produce skin cancers and subcutaneous sarcomas in C57 Black and Strain A Mice by painting and injection.

2. Carcinogenic properties have been demonstrated in fractions of the atmosphere that are free of aromatic polycyclic hydrocarbons. Compounds belonging to the group of oxidation reaction products of aliphatic hydrocarbons have been used to produce skin cancers when painted on C57 Black and Strain A Mice.

3. Ozonized gasoline has been used in inhalation chambers for the production of lung tumors in Strain A and C57 Black Mice. These tumors, while differing structurally from human tumors, are nevertheless unequivocally new growths. Their more indolent natural history in mice may well be a reflection of host resistance factors rather than an indication of lack of carcinogenic potency in the aerosols inhaled.

4. Carcinogenic materials have been identified in the air in a particulate state that permits their being breathed and deposited on the lining of the lung. Many of these cancer-producing agents are chemically stable and, as such, survive sufficiently long after emission from pollution sources to be potential biological threats.

5. Atmospheric irritants of all types as, for example, aldehydes and organic acids, though in themselves noncarcinogenic, may

play a role in the development of cancer by interfering with the normal flow of the mucous stream that permanently resides on the lining cells of the lung. It is this continual flow of mucus that normally serves to prevent the accumulation of deposited material on the respiratory epithelium. Irritants can reduce the activity of cilia, the propelling whips that move the stream along, so that stasis occurs and particle accumulation can follow.

6. Protein materials, normally present in blood and in cells, are capable of freeing cancer-producing chemicals from the particles on which they are carried so that biological activity on their part can result.

The preceding represents biological data obtained through the use of a broad spectrum of mammalian species. I would emphasize at this time that all of the findings represented here were consistently demonstrable in the various species studied. Ample evidence exists to suggest that behavior as observed in the laboratory is closely analogous to the situation occurring in man. It is generally accepted that the development of cancer is a step-wise procedure and, logically, any one of the causative links in the chain can be supplied from other environmental sources. Irritants may come from specific occupational environments, from cigarette smoking, or from the specific biological reaction to repeated viral or bacterial infections. The carcinogenic or cancer-producing agent may similarly be derived from other environmental sources. Atmospheric pollution, however, in and by itself, uniquely supplies the links necessary for the experimental induction of lung cancer. In the absence of evidence or data to the contrary, this observation coupled with the epidemiological characteristics of the disease strongly suggests a similar action for man.

(Dr. Kotin then showed a number of slides to demonstrate some of the points already made. Their content should be evident from his comments on them, which follow.)

Slide 1. This demonstrates the presence of benzpyrene, an experimental carcinogen, in the atmosphere of cities as diverse in their industrial potential as Reykjavik and Los Angeles. It is interesting to note that the primary source of these agents, or *a* primary source of these agents, is the exhaust of gasoline engines.

Slide 2. This is a previously published tabulation of our success in producing tumors in resistant and susceptible animal strains after injection of concentrates collected from the Los Angeles atmosphere.

Slide 3. This is a very brief presentation of the formation of one compound that we think might be in the air. It doesn't belong to the traditional polycyclic group of hydrocarbons. We are convinced of its significance in the laboratory by virtue of our success in producing tumors in both the skin and the visceral organs, and even in the lung itself.

Slide 4. In this table, the numbers are not nearly as important as the valid conclusion that in a highly susceptible strain of mice the production of lung tumors occurs in the test mice at an unquestioned level of significance when contrasted with controls.

Slide 5. This shows a similar study from a highly resistant strain of mice. Again, we see a significant level of response in the lung of levels of exposure that are realistic. The animals lived out their full life spans.

Slide 6. This represents an attempt to demonstrate how noncarcinogenic agents in our environment, as alluded to by Dr. Nelson, can perhaps play a role in this sequential development. They may aid in the pathogenesis of the disease. You can measure the inhibition of particle movement by the use of isolated strips of epethelium, following the exposure of the strips to irritants.

Slide 7. This more or less graphically demonstrates the results. Particles which normally move along the lining of the lung at 9 to 10 m.m. per minute are slowed down appreciably after exposure to a concentration of 1 to 2 parts per million of oxidant.

I personally want to thank the automobile industry for their kind efforts in giving us recently a severe period of Los Angeles smog, so that we have been able to demonstrate a parallel effect with naturally occurring concentrations of smog.

Slide 8. This slide serves a double purpose. First of all, as a pathologist, I would be thrown out of the profession if I didn't show one photomicrograph! Secondly, it demonstrates what happens when the ability to remove the particles that reside in the mucous stream is impaired. You get a beautiful demonstration of the dust accumulation at one level of the tracheobronchial tree. It is a level that is still surrounded by cartilage, which is consistent with sites of cancer-production in man.

Slide 9. This represents, perhaps, a summation of our feeling of the evaluation of the role of polluted atmosphere in the possible pathogenesis of human lung cancer. It is relatively complete, in that pollution sources have been identified, and the pollutants have been characterized physically and chemically. Experimental tumors have been induced. On the basis of what we know about pulmonary physiology, the entry of the pollutants into the lung not only is compatible but has been demonstrated. Their retention in the lung is facilitated by irritants. We have demonstrated again, in the broad spectrum of the species that we used, the effect of these irritants in causing temporary denudation of the lining, with regrowth of the lining after a period of time. We have demonstrated, by means of fluorescent microscopy, the entry of the material into the defensive cells of the lung. We have demonstrated that these carcinogens carried on particles in the lung can be freed in the lung by proteins, in the same way that we can do so by the use of a compound like benzene in the laboratory. Again, we have demonstrated their entry into the lining cells of the lung.

Air Pollution and Cancer (3)— First Discussion of Dr. Mancuso's and Dr. Kotin's Presentations

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The interesting, provocative, and therefore important papers presented by Dr. Mancuso and Dr. Kotin are deserving of much more penetrating and selective discussion than I am capable of giving or than time will allow, or than an ebbing blood-sugar level permits. Therefore I shall confine myself—in a restrained fashion, I hope—to one or two of the general points emphasized.

In his interesting paper, Dr. Mancuso directed our attention to certain types of cancer which are generally on the increase in the United States. While lung cancer properly is singled out as deserving of major attention from the viewpoint of atmospheric pollution, we might well keep an observant eye on other cancers which have an increasing incidence. It is not too farfetched, perhaps, to consider possible co-carcinogenesis from chemicals in the air in the production of leukemia and Hodgkin's disease. One cannot afford to forget, for example, the suggestion of this concept in Dr. Dorn's study of the increased mortality from cancer, generally, in men who were cigarette smokers.

Dr. Mancuso has reminded us of the need for more and better biological tests and means for measuring or determining physiological or pathological changes in humans which may be due to atmospheric pollutants. Perhaps new and better measurements with animal, bacterial, or tissue culture systems should be in a high priority order.

Epidemiological techniques seem to be of equal value to laboratory determinations in many instances in approaching health hazards created by a population exposed to exogenous substances in the air. There is great need for systematic strides in many sections of the United States to procure additional data which may help in appraising the carcinogenic properties of the atmosphere in given localities.

Since we do not know too much about the latent period of cancer, I agree with Dr. Mancuso that unusual attention should be directed to the importance of using residence exposure years as the basic unit to evaluate epidemiologically the cumulative effects of long-term exposure to atmospheric pollutants.

One must agree with Dr. Kotin on the importance of animal experimentation in defining biological effects of many different chemicals and other materials. This speaker has contributed important information to our knowledge of atmospheric pollutants, both from the standpoint of their identification and their carcinogenic properties in experimental animals. The difficulty comes when one tries to relate these data to human experience. Certainly the compounds have been isolated from the air which man breathes; but, there are undoubtedly certain physiological functions and peculiarities of environment which determine the degree of individual exposure and therefore, to some extent, the biological response. The great ingenuity that Dr. Kotin and his associates have shown in experimental laboratories suggests that he has considered the problem of obtaining comparable data from human populations, and I am sure that all of us would like to hear his thoughts on this subject. Is it practical at the present time to measure the individual's exposure to polycyclic hydrocarbons or to other carcinogenic agents that might be present in intentionally or unintentionally polluted atmospheres?

I note that our speaker refers to biological data obtained through the use of a broad spectrum of mammalian species. I am only aware of the published results that have been obtained from the study of mice but understand that carcinogenic potency is not necessarily comparable to physical or chemical properties, since the carcinogenic potency is often related to experimental conditions. It is not uncommon to find an agent highly potent for one species and comparatively noncarcinogenic for another. I wonder if Dr. Kotin could tell us something about the relative carcinogenicity of the various compounds studied in the broad spectrum of mammals.

In closing, I think Dr. Kotin and his group deserve the highest commendation for their work in producing animal tumors by exposure to carcinogens and particularly in one species in which the tumors behave morphologically and otherwise, in a manner similar to those which occur in the human lung.

Air Pollution and Cancer (4)—Second Discussion of Dr. Mancuso's and Dr. Kotin's Presentations

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It is indeed a challenge to comment on these two papers, but in such a short time I shall not attempt to make any scientific evaluation of them. I have a few comments to make and I have one question which I would like to pose.

Dr. Mancuso is certainly to be commended for pointing out that, like communicable disease, cancer is a complex of different diseases with different causes, different degrees of susceptibility, and widely varying rates of growth and development. The analogy drawn between the multitude of organisms responsible for communicable diseases on the one hand and the multitude of chemical compounds responsible for air pollution diseases, if you will, on the other, is also well taken. It is also analagous that many communicable diseases have been prevented long before the nature of the causative organisms was understood.

There is no question that many of the situations caused by air pollution can be brought under control without knowing the exact dose, response curve, and mechanism of action of each component of the air pollutants.

Among the diseases for which air pollution has been incriminated is lung cancer. I doubt whether any knowledgeable person will find fault with the theory Dr. Mancuso discussed, that air pollution is one of the causative factors in lung cancer. On the other hand, we must all admit that the epidemiologic evidence is not adequate to say that the association is one of cause and effect.

Dr. Mancuso made, I am afraid, an unintentional but perhaps serious error in quoting Dr. Hammond, which I think should be corrected. Dr. Hammond did not estimate that 31 percent of lung cancers are due to air pollution. He did make a statement, comparing the rates of lung cancer mortality between urban and rural communities, that when he looked at the urban community there is a 31 percent higher lung-cancer mortality rate than in the rural community. In other words, if the incidence of lung cancer is 100 in a rural community, that in the city would be 131.

However, looking at the relationship to cigarette smoking, Hammond found in urban communities of 50,000 or more that the lung-cancer rate among smokers was not 31 percent higher than among nonsmokers, or even 100 percent higher, but it was 475 percent higher than among nonsmokers. Nevertheless, we are not here to discuss the relative contribution of cigarette smoking and air pollution. Air pollution is a potentially serious factor in lung cancer and to many, this is sufficient reason to get it cleared up.

Dr. Kotin is certainly to be commended for having the courage to go directly to the experimental animal without waiting for the epidemiologist to give a roughly quantitative answer as to how big a role air pollution plays in human lung cancer. Ordinarily, an epidemiologist begins examining the causes of the disease by finding out whether it is of intrinsic or extrinsic origin, and then if of environmental origin, he tries to identify what types of substances are responsible. Then he tries to quantitate in a rough way what is the relative importance of these various agents. Finally, animal experimentation is carried out. Another way that proves a relationship to be established is by withdrawing the responsible agent and noting that the incidence of the disease drops off.

I would like to see a better estimate of the relative contribution of air pollution and smoking to lung cancer in particular, because neither the Hammond and Horn nor the Stocks and Campbell data were obtained with the purpose of obtaining such an estimate. The Stocks and Campbell data are limited somewhat in that they were obtained retrospectively. Such people as Berkson and Dorn and others have pointed out that retrospective studies are not too satisfactory for quantitating the relationship between a cause and a disease.

I would also like to see some epidermoid lung cancers produced by air pollutants. On this point, I was interested to hear Dr. Kotin mention that he had produced tumors similar to those in the human being with ozonized gasoline. I think that this is a very important piece of work.

It may be of interest to you to know that the American Cancer Society's lung-cancer research program is very much interested in air pollution and has a subcommitte which is interested in carrying out such studies.

I would like to just pose one question. I would like to ask for the benefit of the American Cancer Society and other research organizations: It is too much to hope that the potential and known evils of air pollutants will be brought under control before they reach the serious stage which is now being experienced in England, or do we have to wait until definitive proof is obtained that the pollutant from each source is carcinogenic to man before the air pollution experienced from the offending industry or automobile or cigarette is definitely and finally removed?

DISCUSSION

Dr. **Merrill**. I think we are ready now to receive the reports from the six sub-groups into which we divided this afternoon. We appreciate that most of your reports will be informal at this time. So let's start right out with group No. 1, and if things other than answers to the specific question came out in your discussions I am sure we would all be interested in knowing about them. Question No. 1: Are you concerned about the effect of air pollution on your health? The discussion leader is Dr. Irwin.

Dr. Irwin. One thing that we did was to stick precisely to the wording of the question: Are you concerned about the effect of air pollution on your health? We gave ourselves a little latitude in the definition or connotation of the word "concern." On the one hand, we considered that it meant "worried" or "apprehensive," and on the other we interpreted it to mean "assuming responsibility for a critical evaluation." We limited the term "air pollution" to manmade pollution, but we broke that down into acute episodes and chronic episodes. Dr. Goldsmith, who has been our able recorder, will read our report.

Dr. Goldsmith. The conferees were a predominantly professional group of 30 persons who had come to the National Air Pollution Conference not because of personal concern but largely because they were concerned with the possible effect of air pollution upon others.

The group felt concern about their own health in the sense of responsibility for the critical evaluation of both acute and chronic effects of air pollution. They did not feel concerned in the sense of being apprehensive about the acute effects of air pollution; however, about one-third of them did feel apprehension about chronic effects of air pollution on their health.

The group attempted to compare their concern about air pollution with their attitude toward other hazards. Concern was unanimously less about air pollution than about the risk of automobile accidents. About one-third felt greater concern about air pollution than about bathtub accidents, while two in three felt less concern. About equal concern was felt about smoking as a health hazard as compared to air pollution.

About one-third of the conferees felt that in their own community there was no air pollution. Most felt that there was insufficient information upon which to base concern for their own health. The conferees were unanimous in feeling concern about the effect of air pollution on health when the question referred to their community rather than to themselves.

Dr. Merrill. Number 2—what proportionate level of financial support should be given to research on the effects of air pollution on health? The discussion leader is Mr. Griswold.

Mr. Griswold. We arrived at the unanimous conclusion that the question asked of us—what proportionate level of financial support should be given to research on the effects of air pollution on health—was one that could not reasonably be answered. I don't think that it should reasonably have been asked, because any statement that we might make would further limit the U.S. Public Health Service in carrying on an effective and fluid program in the overall study of air pollution. We were of the opinion that there should not be any fixed amount placed in the legislative authorization for continuing this program, nor should there be an annual limitation on the amount of funds that could be spent in any one year.

We were unanimously of the opinion that a certain amount of administrative discretion should be utilized in carrying on this program;

that there should be a potential for shifting the emphasis from the engineering aspects to the medical aspects within any year or within any short-term or even long-term program.

We are also unanimous in feeling that the air pollution agency should become a fixed part of the U.S. Public Health Service and not be continued on a year-to-year or 5-year to 5-year basis: that air pollution in its recognizable characteristics is here to stay and that the characteristics today may not necessarily be the important thing tomorrow or next year; that eye irritation, while it is a nuisance today, may not really cause serious health hazards and may not be causing them today; and that there is much work to be done in both fields, engineering and health, which should be carried on under a long-range program. I would like our recording secretary, Dr. Mancuso, to read our unanimous statement to you.

Dr. MANCUSO. The statement of our group is as follows: As an introduction, the public interest and response to air pollution is indicated by the rapidity by which scientific forces have been mobilized, and this interest and response has made possible the growth of the Federal air pollution program from about $1 million a year to $4 million in the fourth year of appropriations. We have made four points:

> 1. It is recommended that there be a permanent extension of Public Law 159 without limitation as to time or appropriation. The proportionate emphasis on research should be on a year-by-year basis, depending upon the need and the advances of knowledge at that time. We expect this to be a long-term problem, and perhaps of changing character as older elements of the problem are alleviated and controlled and newer problems arise to be solved.
>
> 2. In view of the number of problems needing attack for which research potential is not being utilized because of lack of funds, it is recommended that the air-pollution program be significantly expanded.
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> 3. Because of the pressure for medical answers to provide an intelligent basis for control operations, there is urgent need for acceleration of medical research.
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> 4. The opinion was expressed that the automobile industry should carry some of the responsibility for research relative to auto exhaust and that research into the general composition and effects of community air pollution is a proper Federal responsibility.

Dr. MERRILL. Let us go on to Number 3. What is the responsibility of the voluntary health agency in the air pollution field?

Dr. WHITTENBERGER. The prevention of community air pollution is by nature a responsibility of public health agencies. However, since air pollution affects human health and welfare, voluntary health agencies may assume interest and responsibilities in this field. Professional societies such as the AMA, APHA, and so on, might be said to have a responsibility to undertake research and educational efforts in this area. Other voluntary health agencies such as the National Tuberculosis Association and the American Cancer Society can be expected to become active in the air-pollution field because of their desire to prevent the diseases with which air pollution is associated.

The group put highest emphasis on the need of voluntary agencies to promote and support research. Because the diseases which have been implicated in the air-pollution problem are numerous and varied, including such widely divergent conditions as chronic bronchitis, emphysema, lung cancer, asthma, tuberculosis, and heart disease, the group suggests specifically that the Public Health Service invite representatives from agencies representing each of these disease categories to plan a followup study of the effects of air pollution on mortality and morbidity of these diseases. Such agencies as the American Heart Association, the National Tuberculosis Association, and the National Cancer Foundation might be included.

The second activity of voluntary health agencies on which there was strong agreement was in the field of education. It was agreed that, even with our existing state of information about the health effects of air pollution, voluntary health agencies should promote education of the public. One specific way in which this could be done would be to give more publicity to such activities as Clean Air Week. Education should be promoted at the professional level of physicians and other health workers, both through undergraduate medical schools and through postgraduate courses.

It was believed that, in particular, the professional societies which represent the various health workers should be involved.

One of the suggestions of the committee involves a barb which might be directed to those professional societies which have assumed a certain amount of responsibility for the health of the Nation. These agencies should be asked whether they have concerned themselves sufficiently with the prevention of disease which is caused or aggravated by the atmospheric pollutants.

A third activity of voluntary health agencies which should be promoted is the providing of leadership and responsibility for support to public health agencies. It is recognized that voluntary health agencies have something peculiar to offer. They are, by definition, voluntary. They have used a great deal of missionary zeal with which they attack health problems, and this kind of leadership can be very important in assisting the activities of the public agencies.

Dr. **Merrill**. Group 4—what is the responsibility of practicing physicians in the air-pollution field?

Dr. **Smart**. One of the chief considerations of our group was the lack of information on the problems of air pollution among the practitioners of medicine, and the fact that during periods of air pollution patients are going to their doctors and saying, "Why don't you do something about air pollution? Does it harm my health?" and so on. So most of our recommendations are related to those questions.

First, we recommend that the proceedings of this conference be made available to all physicians, public health authorities, and to legislators having responsibility to the community for the control of air pollution.

Second, the local medical association should be responsible for collection of information regarding air pollution generally—on the health effects of air pollution, or the possible effects, and also on their own local problem. This information should be made available to their members and through them, of course, to individual patients.

Third, the county medical association should have programs for its members on the problems of air pollution, with discussions pro and con. Preferably the panel method should be used, so that all aspects of the question can be discussed. In this way it would be possible to bring in experts in other fields, who are not strictly practitioners of medicine, such as toxicologists, chemists, engineers, and so on.

Fourth, the county medical association should publish information on air pollution in its local bulletin from time to time. This means, then, that the county medical association must make this an integral part of its activities and probably should have a committee on air pollution, providing, of course, that air pollution is a problem in that community or a potential problem.

Fifth, we should ask the American Medical Association to publish information nationally regarding air pollution, giving a good deal of the information that has been presented at this conference, because there is a great need to inform doctors regarding the development of this problem and some of the unanswered questions and some of the conclusions that will come out of this conference.

Sixth, private physicians should be encouraged to use local facilities in the diagnosis and management of clinical problems involving air pollution. In other words, there are many patients who are going to consult physicians and say, "Now, I think my asthma is due to smog," or "I live so close to this plant that I think I am being poisoned with lead or sulfur dioxide or something else." In many instances a private physician does not know to whom he can turn for information in the diagnosis and management of these problems.

In our community there are men working with base metals, and probably there isn't one doctor in a hundred who knows that these facilities are available.

Seventh, physicians as a group should advise and act as consultants to local legislative bodies regarding prospective legislation to prevent air pollution. There are many places where it is known that new industries are coming in. A great deal could be done to prevent air pollution if regulations and laws concerning the control of effluents were established before the industry actually built its plant. This, of course, is already being done in some areas, and I am sure that in our area one of the reasons that Mr. Griswold in his district has made the progress he has is that a lot of new plants can't come in unless they do certain things. In other words, we have to prevent air pollution as well as cure it.

Eighth, it is felt that postgraduate courses should be given for local physicians regarding air-pollution problems.

Ninth, most of the above with regard to county medical activities has been suggested because of the lack of information on the part of the average physician who is responsible for the care of his patients. These physicians should be well enough informed to reassure their patients, when reassurance is justified, and thereby avoid hysteria and dissemination of misinformation. We are all agreed that we must not let misinformation get into the newspapers and have hysteria. This is only going to boomerang and defeat a well-conceived air-pollution-control program.

Tenth, physicians should be informed as to where they can get reliable information concerning a specific air-pollution program. Now, this will vary in many communities. In our community we have had for several years well-organized air-pollution-control districts with a large staff of trained specialists. It is very easy to pick up the phone and talk to Mr. Griswold or one of his associates, but I am sure there are many communities where those facilities are not yet available. We felt that probably the local health department would be the first place the doctor should turn if he is not able to get the information from his county medical association, and certainly we hope that all of the State health departments will be able to act as consultants to our practicing physicians.

Dr. Merrill. Number 5—how would you estimate the impact of air pollution on your community needs? Mr. Rees.

Mr. Rees. Practically all the conferees have agreed that really we can't agree on what the question means, and that, if we could agree on what the question means, we don't have the data available to give you a specific answer.

We had all types of people in our subgroup. For example, I am a person in public office who has to run for reelection every 2 years. Air pollution in southern California always seems to hit just before election time, so I can estimate the effect on the public health by all the people that start writing me letters, coming around to my office, and calling me up at 2 o'clock in the morning. It has affected my health as a person living in an air-pelluted community, and it affects my sleep and well-being when I am trying to worry about the other party and not air pollution.

In our group there were doctors and family physicians who estimate the public health in terms of the people who come in and say they have eye trouble because of air pollution. There were health officers from communities saying that, as far as we know from all the available data, we cannot actually trace air pollution to any serious illnesses, although there is work going on and tendencies are being shown.

We had people from communities which have not had an air-pollution problem as yet but anticipate an air-pollution problem, and they weren't really estimating much in terms of impact on public health because the impact, if any, would be coming up for the future.

We can say that the data available now are surface data on certain experiences that we see. How does it affect people's health? It affects their eyes. It makes them uncomfortable. In Los Angeles I know it affects our dispositions. We have had testimony before one of my legislative committees from a psychiatrist saying that there is probably a tie-in with the mental health of the people affected, in relation to how they would act at their home or in their office.

We then discussed questions of major health problems, and what is an air-pollution program, and we came to the conclusion that most programs in the United States have been set up because air pollution is a nuisance, not because it is a health menace. The group mentioned that in Pittsburgh and St. Louis and also in Los Angeles we are worried primarily about abating a nuisance, and that right now we are beginning to worry about health, so that, in recommending anything for the future, about all we could recommend is primarily what is happening right now. We said we should continue as we are continuing now with a definite program in medical research at all levels, and we hope that this can be expanded.

Also along with this we felt we should continue a very strong abatement program based primarily on the abatement of a nuisance; that we can't afford to wait 10 or 20 years for definite medical results and find out perhaps that all of our people are going to be very seriously ill of lung cancer or some other pulmonary disease.

These were our principal recommendations:

First, that we were unable to agree on any one method of assessing the impact upon the health of a community. Another is that we are afraid that if too much is talked about in the field of public health it might cause hysteria, which could be bad. For example, if Los Angeles were under a 3- or 4-day inversion we might find a mass exodus out of the Los Angeles Basin, and our freeways are crowded enough without that. This could cause panic in the metropolitan area.

There is also the problem of hysteria in terms of affecting the lawmaking bodies. We don't want to get hysteria so bad that a legislative body could, by passing laws, definitely cripple certain economic factors of our society.

We also agreed that we had limitations as a panel and that we did not have the technical knowledge to give a very definite assessment of the effect on public health. Our last recommendation was that we continue the programs which we do have, both in the health field and in the abatement field, and try to increase them in the future.

Dr. MERRILL. Number 6—what should be the responsibility of government—Federal, State, and local—in the determination of the health effects of air pollution?

Dr. NELSON. We had a broad representation from essentially all fields which might have some responsibility entirely aside from governmental. We took a poll, simply to get a distribution of the various agencies present, with the following results: We had five from Federal agencies, including not only health but others. We had six from State agencies. We had three from local health agencies, and we had about five or six from industry. We had one from a voluntary health agency. We had three from universities. The group grew, and I think that this pattern was about representative throughout the meeting.

The first point which became apparent is that a determination of health factors of air pollution is perhaps the foremost one that faces people concerned with air pollution problems at the present time. It was recognized that the nuisance effects are at the moment the most direct and objective way of securing control. However, those involved in control procedures stated again and again that their control would be much more effective, straightforward, and forceful if they could have recourse to measurable and objective information on health effects of air pollution. This, then, defines the urgency of the question and is quite aside from the need for an adequate definition of health effects.

In terms of whose responsibility this should be, in the first place it was quite apparent that there was general agreement all through that it should by no means be limited to the governmental agencies; namely, the Federal agencies, the local and State health organizations. On the contrary, other parts of our society have responsibility for it. These include industry in a very real degree, and the voluntary health agencies and universities and those others qualified to contribute to this problem.

However, with regard to the responsibilities of governmental agencies, the entire group concurred that when air-pollution problems are national in scope the responsibility rests with governmental agencies at all levels, Federal, State, and local. In the rarer circumstances where air-pollution problems were localized and restricted in nature, they would be the primary responsibility of the local health agencies which could properly look to State or Federal agencies for advice and guidance in their approach to this problem.

The team approach was emphasized throughout. Many groups cannot deal with this problem independently without aid from others; it requires cooperative effort at all levels.

It was suggested that a great deal more could be done than is now being done; that there were resources available at State and local levels which were not being fully exploited; and that these could be tapped by various means. One possibility would be to suggest certain kinds of health inquiries, or kinds of health statistics to be secured, providing the appropriate agency with a pattern as to how these data should be gathered and correlated.

It was also felt that education and further information would help to make available various resources at the local levels. On the other hand, it was felt that further funds and resources may be required at the local level, over and above these existing sources.

In general it was felt that, although more needs to be done by all of these governmental agencies, it is not to be expected that this would be accomplished on a crash basis, and that this might, in fact, lead to a misuse of the resources available.

There was, however, evidence that a lot more support could be effectively used at this time. Although a crash program is not to be recommended, a more intensive and aggressive effort with additional support at the various levels of government is in order and should be encouraged.

DISCUSSION GROUP "D"
ECONOMIC AND SOCIAL EFFECTS OF AIR POLLUTION

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Theme

"What Does It Do?—The Economic and Social Aspects"

Questions for Discussion

I. Where do we stand, and what should be done further, as to knowledge of—
  (*a*) the economic worth of clean community air?
  (*b*) the cost of having clean community air and of not having it?

II. From social and esthetic considerations—
  (*a*) should our community, and its air, be as clean as our homes?
  (*b*) who should pay to maintain such cleanliness?
  (*c*) is such cleanliness worthwhile in its own right, or only when justified specifically by economic or health considerations?
  (*d*) can we afford such cleanliness?

Impact of Air Pollution on Our Economics (1)—Industrial and Community Development and Property Values

Dennis O'Harrow
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About 8 years ago I was working in an industrial city, a city of heavy industry. The year before I arrived there, a reluctant council had passed, by virtue of pressure from garden club ladies and a social register mayor, a smoke-abatement ordinance. However, in the elapsed year nothing had been done to put the ordinance into effect. Now, a year later, the garden club ladies had again risen in their wrath, and the council had been forced to authorize the hiring of an air-pollution technician; the technician had been engaged, had arrived, and had been given a desk in one corner of the city engineering office. Steps were about to begin to be taken—maybe.

I asked one of the councilmen why there had been such a long delay in starting to clean up the air around this city.

"You ain't seen nothing yet," he said. "Smoke is still here, and my guess is that it always will be."

Then he pointed out the window to a black cloud pouring from one of the stacks in the valley. "See that? That means work. No smoke, no work. The people don't want to get rid of smoke because smoke means jobs."

So far as I know, the smoke-abatement ordinance is still not really enforced in that city.

The heavy industry in the city was steel—an industry with a history over the years of long and costly shutdowns, lockouts, and strikes. When there was no smoke coming out of the stacks, there had also been no money in the pocketbooks to buy groceries, no money to pay rent, no money to buy clothes, medicine, and liquor.

So, smoke was equated with jobs and clean air with empty purses.

I relate this because I think it illustrates a basic problem of symbolism which is even more difficult to solve probably than is the technical problem of maintaining clean air.

Not that the equation "smoke equals jobs" is a belief widely held for which people would fight, because I doubt that it is, except in the vicinity of a few heavy industries. But the use of symbols in place of reality is ever present in the attitude of people. It must be reckoned with in any movement toward the correction of longstanding maladies in the body politic.

If you were to take a poll on the prevailing symbolic beliefs about industry, I am sure, however, that the winning belief would be something like this: "Industry means smoke, and we don't like it and we don't want it near us."

It is a prevailing belief that industry and factories mean not only smoke, but also other kinds of air pollution, including noise. And factories mean ugliness and dirt, and ugly, dirty factories mean slums, and slums mean crime, vice, and disease.

It takes no great insight into human nature or wide knowledge of modern civilization to understand how people arrived at the smoke-dirt-ugliness-disease symbol for industry, because in the past it was probably a completely accurate description, more often than not. It was no symbol: it was the truth.

But these symbols die hard. One of the interesting things about city planning is that you can always rely on the local scenes to give you a case in point. No matter what aspect of city planning you are talking about, this is true. In yesterday morning's paper, I found this (it was in an article about the problems of the new Atomic Energy Commission offices in Montgomery County, and I quote):

"The General Manager said that AEC also is concerned over the rezoning by Montgomery County to light industrial use of 110 acres directly across from the Agency. AEC protested the zoning change.

Its officials fear the clear rural area will eventually have its air polluted by smoke, smells, and noises from the industrial section; also, that it will create traffic and other problems. All these things AEC thought it would escape when it went to Germantown. Some Federal officials feel so strongly about rezoning that they would like to see the Bureau of Standards, which is planning to move, either cancel or postpone its projected move to nearby Gaithersburg until the county adopts fixed zoning standards around the Government building."

Symbols die hard, even in such an enlightened area as Washington. For example, noise is generally considered to be a common sin of industry. During the past 10 years, in a number of careful studies, the noise from manufacturing process audible from the outside has been carefully measured. The general conclusion is that in 90 percent of the older plants the noise level from industrial processes, measured from the property line, is below the regular noise level of street traffic in front of the lot.

I said that these measurements are for older plants. For new plants, factories built since 1947, I am sure the processed noise level at the property line would be insignificant in 98 percent or more of the plants.

Which brings me to the statement that you can divide all industrial establishments into two kinds—old and new—which is also to say that the industrial plants built today have only a faint resemblance to those from which we acquired our symbol of smoke-dirt-ugliness-disease. I don't need to describe them in detail; you have all seen them: one-story, modern, with clean architectural lines, set well back from the road with beautifully tended lawns and flowerbeds in front and ample employee parking in the rear.

And, perhaps best of all, more and more they are using smokeless fuel and discharging no pollutants into the air.

Probably one of the most revealing characteristics of new industry is the ample sites used and the low proportion of the land covered by buildings. In a recent survey of industries in a metropolitan region outside of Detroit, it was found that the average ground coverage for all industries was 10 percent of the lot covered by buildings and that half the major industries covered 5 percent or less of their land. For contrast, you will find that in the average suburban residential development, the house will cover 15 to 20 percent of the lot. Five to 10 percent coverage for a one-story modern factory is also quite different from the old factory with 90 to 100 percent coverage of the land by a 5- to 10-story building.

The public attitude toward industry leads us to believe that there is a great schizophrenia abroad in the land. On the one hand, we don't want industry in our town because of the smoke and dirt symbol; on the other hand, our local taxes are so high, our school finance problems are so overwhelming, we must have industry to help us bear the burden. In one-industry towns, we must have more and more diverse industry to decrease our vulnerability to strikes, to the vagaries of the business cycle. In underindustrialized areas, we must have industries to furnish jobs for our kids so they won't leave home as soon as we've got them educated.

These are all true needs: industry is important in spreading the taxload; diversified industry is important in maintaining steady employment; and industry is a necessity for maintaining a reasonable import-export balance of human resources. There is also some warped symbolism here, but, on the whole, these are legitimate needs of a community.

As a consequence of our aching desire for industry, we establish industrial development agencies in State and local government. We build factories for private industry, pledging our public credit to the purpose. We buy advertisements in the New York Times and Fortune magazine, we select the prettiest girl in town and exhibit her in a bathing suit—all to tempt industrialists to come to our State or our city to manufacture gimmicks or gadgets.

But all the while, back home, there is this other personality of ours, this schizophrenic alter ego. We want you, but, by golly, we don't want you anywhere near our house, because you are smoky, dirty, ugly, and you breed disease. And, also, you run down the value of our property.

If any of you ever have need to make an objective study of the effect of any particular phenomenon on property values, you may be in for a surprise. It is fantastically difficult to isolate such matters. You generally come up with the most tentative kind of answer, hedged about with hordes of ifs and buts. Researchers are not discouraged; they will try to determine the influence on property values of such miscellaneous things as, say, churches, filling stations, expressways, minority groups, and so on. Not only is it difficult to make a quantitative determination of effect; it is usually just as difficult to tell which direction values went, up or down.

To use an unfair but quite accurate illustration: there is quite clearly a cause-and-effect relationship between the old-fashioned dirty factory that slipped into a mixed industrial-residential district before we had zoning, and the blight and slum conditions of the residences in the same district. But take a real hard look at the value of those slum residential properties. They are extremely valuable, because the landlord, who, of course, does not live in the neighborhood, gets an enormous return from them without having to invest a single penny in maintenance. They are also assessed at a very low figure, so the taxes are insignificant. But try to buy one of these properties and you'll get a clear and definite idea of the value placed on it by the owner. You will find that it is considerably higher than a comparable (if it were possible to compare) nonslum property.

Please do not think that I urge that we erect more dirty factories in residential districts in order to create more slums to build up the value of property. It really isn't a practical way to create real estate values any more. This is partly because of zoning controls, but principally because factories are no longer dirty per se and industrialists no longer want slums. In fact, intelligent industrialists will go to great lengths to avoid creating slums, and they completely refuse to build in slums.

I said that researchers have a great difficulty in trying to single out the effects of a particular environmental phenomenon on real estate property values. In fact I have not been able to find even a single attempt to determine the effect of industry—of modern industry—on property values. I feel quite sure, however, from observation around the Nation that, on the whole, new industry increases the property values. You have, for example, the spectacular increase in property values such as those in the neighborhood of the Fairless plant of United States Steel near Philadelphia; the Ford plant at Milpites in the San Francisco Bay area; General Electric's Appliance Park outside Louisville; the Chrysler, Ford, and General Motors plants in the Cleveland area. There are hundreds of smaller and less well-known industrial developments which have also resulted in increased property values in their neighborhoods.

When you think about what industry does to a city, more specifically, what it does to property values, you should not forget that the effects are sometimes quite widespread, the ripples are not necessarily damped off within the first mile.

A couple of years ago Ford announced that a new $30 million stamping plant was to be erected in a neighboring city near the village in which I lived. The plant was actually to be built about 8 miles from our village limits. Within 2 months after the announcement real estate prices jumped 10 percent in my village—if you could have found a house to purchase. The supervisory force that Ford was transferring from other plants to the new one had come down en masse and had bought everything available in our village.

I am sure that everyone in this audience can cite examples of the enhancement of property values by the location of new industry.

Still we find this conflict in ideas—we need it; we want it; we must have it to survive—but please put it on the other side of town.

I have said that industry is not smoky, it is mostly smokeless; it is not dirty, it is clean; it is not ugly, it is beautiful. And—well—it doesn't produce disease. I have said this about modern industry. I have said that there is in the minds of the public a symbol, a bogeyman.

At the risk of confusing you, I want to contradict myself—or at least to modernize the symbol to correspond with modern industry.

While the annoyances of smoke, fumes, noise, vibrations, glare, dirt, and ugliness of the factory and its processes are pretty much things of the past, they have been replaced by the fumes, noise, vibrations, dirt, and a true physical safety hazard from the traffic, from the rubber-tire traffic generated by modern industry.

This nuisance people object to, and I fear there are not many very convincing arguments to make them change their minds.

Solving the problem of industry-generated traffic calls for a lot of things besides air-pollution-control measures. I would not even guess what the eventual solution of the traffic problem will be, but I feel quite sure that there will be no lessening from today's traffic level. Eventually there must be a saturation point beyond which auto traffic cannot increase, but that limit is nowhere in sight.

This means that the share of air poisoning that can be laid to auto and truck exhausts will increase with the increase in traffic. And the share of annoyance with industrial traffic that comes from its air-polluting activity will likewise increase.

At this point I should like to put in a word about two particular groups of industries that I have ignored so far. One group is that of the older industries that are polluting the air because they always have done so and because they have not been forced into cleaning up, even though cleanup devices are known and available. There is in this group a subgroup which would include those marginal operations that can exist now in competition with their cleaner and newer brothers only because they are not forced to clean up. They would go under, go bankrupt, if they were required to stop polluting the air.

The second special group takes in those industries such as petroleum refining which, in spite of our speech yesterday, has not yet found any way to avoid polluting the air, even though they are trying to discover economical cleanup devices.

I shall not suggest any methods for treating these groups of industries, because I am sure that their woes will be discussed thoroughly in other sessions of this conference. But I shall say that, from the standpoint of community development, they are blighting influences and will continue to be blighting influences until they stop polluting the air because they either are cleaned up or shut down. The citizens and the city fathers should make up their minds to this. It is useless to think that by any methods you can attract a decent, clean industry these days to locate in the pall of such blankets of air pollution as some of those industries lay down over the surrounding landscape.

It isn't possible to summarize briefly a subject as amorphous as the relation of air pollution and community industrial development. I do think it important to realize that in the community we are working with a symbol of industry which is no longer valid, but one which air pollution did much to build up.

It takes no deep study of national economics to recognize that industry is an indispensable part of the national economy. Nor does it take any great gift of prophecy to know that the amount of industry and the amount of new industry will continue to increase for as far into the future as you would care to foresee. These new industries must be placed somewhere; they should be placed in the best possible location.

They are not always going to be placed in the best spots unless we get a new symbol, a new picture of the new industry in the minds of citizens, civic leaders, and city officials.

There is that side of the problem, and there is also the other side. There is still much work to be done in cleaning up the present air pollution. From the viewpoint of a particular city, such as the petroleum-refining center of Whiting, Ind., this may be the whole story. In some of our cities, someone may have to sit down and do a plus-and-minus, dollars-and-cents job in some cases, figuring out which is more economical, to buy out and destroy one plant or to let that plant continue to operate, continue to pollute the air and destroy the neighborhood or the entire community.

Finally, there is something that we must all remember. If you reduce the polluting discharge from 1 plant by, say, 50 percent, theoretically you have cut the air pollution in half. But if a second plant of the same kind and the same cleanliness comes into the area, you are back where you started. And if a third plant somes in, you've got 50 percent more junk in the air than when you started. This means that we must shoot for complete cleanliness, not just enough scrubbing up to get by with for the present.

Just to show you that there is a good prospect that the second and third plants—and maybe the fourth and fifth plants—will come into our urban area, I heard one of the Nation's leading population experts state just 2 weeks ago that if the birth and death rates in the United States maintain the postwar level for 100 years—until 2050—there will be 1 billion people in these United States. That would mean about six plants for every one that we have today.

And, after all, 2050 is not 100 years from now, it is only 92 years more.

Impact of Air Pollution on Our Economics (2)— The Homemaker's Viewpoint

Miss Chloe Gifford
President, General Federation of Women's Clubs
Washington, D.C.

(Read by Miss Sally Butler)

I have given serious study to the problems of air pollution since the day I was invited to participate in this conference. I know that air pollution poses problems which challenge the ingenuity of an extraordinary variety of talented people, ranging from engineers, doctors, and chemists, to meteorologists, statisticians, and lawyers. Also, I have learned a good deal about the awesome destructiveness of air pollution. I have learned it can threaten human health and even cause death. It can hasten the decay of stone buildings; destroy farmers' crops; ruin the paint on a house or a painting in a museum; sicken and kill livestock; soil or corrode almost everything; and on occasion, blot out the sun. Except for such catastrophic upheavals as war, earthquakes, and floods, air pollution threatens people and their property in more different ways than any other single problem I know of. Therefore, we realize that air pollution is a social and economic problem of very formidable dimensions. This fact may be common knowledge among most of you who are here today, but I feel that it is knowledge which is all too uncommon with people on the community level.

The general public, more than half of whom are women, has not been given sufficient education on all the complexities and ramifications of air pollution. Realizing this, I perceive the outlines of an additional problem, which in the long run will require just as much effort and emphasis as any of the outstanding scientific and legal problems already on your growing list.

It seems apparent that two principal needs must be fulfilled if the threat of air pollution is to be banished. First, much more needs to be learned about air pollution, particularly about basic effects and methods of control. Second, methods of control which are now available need to be much more broadly and intensively applied to avert ill-effects we already know about. Both these needs depend on public knowledge and understanding. Whether your main purpose is to gain time and funds to expand research activities or to find means of augmenting the application of existing controls, an informed public, and particularly informed women, can help you. But first they must be given the full story concerning air pollution; they must be taught that control needs benefit from research efforts and research efforts depend on control experience for substance and direction. Whatever facet of air pollution you are primarily concerned with, you can benefit by a comprehensive educational effort to properly inform both contributors to air pollution and the public who suffer the ill effects of it. There are many obvious reasons why this effort is needed, not the least of which is that, in the long run, the responsibility and expense for clean air will inevitably fall upon the collective shoulders of the public.

In one city in particular, Los Angeles, the public has been alerted to the threat and it has responded admirably. A public education program was not needed to convince people that the problem needed attention, but the people did need to be educated as to what they were up against and what they would have to do and how much they would have to pay. In Florida, where the phosphate industry has caused a real air-pollution problem, there is damage to human health and comfort, damage to cattle to the point where profitable ranching in that area is approaching extinction. Furthermore, there is damage to trees and plantings. Poisonous pollutants are absorbed by leafy plants used for food. It is said that the plants are toxic.

In Florida, club women are vitally interested in these problems and are conducting a program of education and insisting upon legislative action to remedy the situation. Such programs are overdue in many other areas where you don't need an air sampler to tell you that the atmosphere is unpleasant. We know that these areas are bound to get larger: that the heavy concentrations of people they already hold are bound to become greater and the amount and diversity of human activity which creates air pollution is bound to increase. Somewhere along the line the American woman is bound to make certain that the air her family breathes is clean. The sooner she is given full information on the problem the more intelligently and the more dispassionately can she do her part in combating it.

We have no time to lose. While all the calculations are being made and all the various kinds of studies are in progress, it is largely the women of the country who will have to patiently take care of all the dirty work caused by air pollution. It is the woman, primarily, who will be wondering whether there is any connection between the dirty air and her children's sicknesses. It is she who will notice that the clothes she launders are often stained gray or black; who will notice that the collars on her husbands shirts are ringed with black, despite his faithful participation in the American ritual of the daily bath. Even if we fail to educate her in an understanding of air pollution, she will be constantly reminded of its effects—in the amount of clothes she has to wash; in the depressing effects of air pollution on the interior walls of her home, which in many localities have to be washed or painted every year at considerable labor and expense.

More and more the woman will notice as she looks out her windows that the world outside is often gray and drab, not only because the air is that way, but also because the windows themselves are continually filmed with dirt despite regular washings. She will notice that certain plants will not grow well in her yard, despite the fact that the instructions on the package insist that the plants were made to grow in the climate in which she lives and the type of soil which she has. In more and more cities she will be noticing that the sun often rises and sets improperly, it rises an hour too late and sets an hour too early.

She will notice more and more often that the outside air doesn't smell right. More and more she will notice also that the snow which is supposed to bring a white Christmas brings a gray Christmas by 3 o'clock in the afternoon. She, even more than her husband, will continue to notice so many dozens of manifestations of dirty air that, sooner or later, she is bound to wonder whether filling our towns with an incredibly complicated mixture of obnoxious gases and dusts is not a ridiculous anachronism in contemporary American life.

So far the American woman, both the housewife and the working woman, has displayed an amazing tolerance of dirty air. Day by day, however, as the incongruity between our other high standards of sanitation and our careless use of the air becomes more pronounced, this tolerance is bound to wear thin. It is the woman who has the most direct appreciation of the scientific wonders which have been brought into our homes during this century: of the incredible medical advances which assure that her children will not be pockmarked; will not have to fear such great killers of the past as scarlet fever and cholera. We hear a lot of talk nowadays about the strains and stresses of contemporary life, about the anxieties that city people today seem to share in larger measure than their rural ancestors, but we don't hear enough perhaps about the anxieties the modern mother does *not* have to suffer. She has been assured by an intelligent science that dozens of perils once believed unavoidable are no longer worthy of her worry. She has been assured that the water which comes out of her faucet will be absolutely fit to drink, that when her children need vaccine it will be available at a price within her reasonable reach, that the medicines she buys in the drugstore because of pure food and drug laws can be safely used in accordance with the instructions on the label. As our living and health standards continue to rise and the factors of population, concentration, and production increase, it is certain that the darkening air will become a constantly growing incongruity in the midst of all the other clean, wholesome products and privileges offered by life in a thriving modern society. There is already a striking contrast between our standards of cleanliness as applied to the interior of our homes and our persons and the outside air. We fight dirt with brooms, vacuum sweepers, washing machines, brushes, soaps, and antiseptics, then walk outside into air laden with dozens of different kinds of filth.

Not so many generations ago, in many of the countries which today are among the most advanced technologically, it was common practice to throw garbage into open sewage ditches. Today, we look back on that kind of thing with amazement. However, open sewers were less amazing in the technologically backward world of a few generations ago than it is amazing today to observe that many cities and towns in the most technologically advanced nation in the world have allowed their precious supply of fresh air to become an open sewer of sorts.

The longer we wait to educate the public to the necessity for solving this problem the greater becomes the risk of some unsuspecting city becoming another Donora. If this should happen, the public's tolerance may end with a bang and it will be too late to whimper. It will be too late to explain that we don't know all about the things that cause air pollution. It will be too late to apologize for the fact that we failed to let the public know that there *are* methods of controlling many air pollutants and that we did not have enough public support to find out soon enough about the others. If this should happen, I fear we will all pay, every single taxpayer and consumer among us, an exorbitant price indeed—both morally and financially.

I believe everybody in every town and city, regardless of whether the citizens face a recognized air-pollution problem and regardless of whether they seem to care, should know the facts of air pollution. In most places throughout the country, the people have not been sufficiently well informed to know whether they should care or not. Women do know that in some areas it requires more work and money to keep their homes and families clean than it does in others. They have not been taught, however, that to a large extent, this difference is a correctable or preventable effect of air pollution. They also do not know that the efforts we all make to keep our environment healthfully clean in the midst of air-pollution costs more than adequate controls would cost.

As matters stand now, it appears that the citizens of a few cities are carrying a disproportionate share of the Nation's air-pollution burden. While it is certainly true that each town and region has its own peculiarities of sources, geography, and meteorology, it is equally true that all areas of our country have many of the same air-pollution problems.

I am sure that this conference has focused enough public attention on air pollution that we can consider it a good beginning toward better public awareness. When the conference is over, all of us through his own efforts and organizations should support a continuing effort to inform the public. The American woman will give intelligent help in almost direct proportion to the amount of intelligent information she is offered. The American woman is not only a great factor in the stimulation of public opinion but is also a dynamic power in helping to bring about legislation that will promote the health and welfare of her family.

Impact of Air Pollution on Our Economics (3)—Agricultural Considerations

Charles Butler
Director, Land and Water Use Department
American Farm Bureau Federation
Washington, D.C.

The Nation's agricultural industry has a twofold interest in air pollution. Its major interest results from the constantly increasing loss of millions of dollars annually caused by air pollutants which are foreign to agriculture. Of secondary importance are certain forms of air pollution for which argiculture is responsible.

The tremendous economic losses which agriculture suffers annually are caused, for the most part, by industrial developments in close proximity to producing agricultural areas. Most of these losses are in the form of damage to livestock and crops. It has recently been estimated that the anual loss to crops in the Los Angeles, Calif., area alone is in excess of $5 million. Extensive losses can also be cited in many other States such as Oregon, Washington, Montana, Idaho, Utah, Tennessee, Florida, and New Jersey. In these areas damage from air pollution ranges all the way from a slight reduction in crop yields to the loss of the entire farm enterprise.

Historically, some form of agriculture was the first industry in most areas of the country. As long as there were no industrial developments, there was little, if any, air pollution. With the development of certain types of industry, such as the production of aluminum, manufacturing of steel, processing of phosphorus fertilizers, and other manufacturing processes, economic losses to agriculture started to mount.

Because of these losses to an established agricultural industry, caused by new industrial developments in the area, it seems reasonable to ask the question: Has a property right been taken from the farm owner as the result of the air over his farm being polluted? Since, through no fault of his own, he can no longer produce livestock and crops as previously, it seems reasonable to believe that a property right has been damaged or taken away completely. This being the case the farmer should be paid just compensation for damages to his enterprise.

It is extremely difficult to evaluate just compensation for various degrees of damage to agriculture. Perhaps the damage is limited to a small reduction in crop yields or possibly a farmer may be required to market his produce as second or even third grade because he is located in an area affected by air pollution. Possibly he is forced completely out of the type of livestock or crop production which he desires to produce, or he may be forced to abandon his farm enterprise completely and move to another location. How are these various degrees of losses to be evaluated? Who is going to put an evaluation on them?

To date such losses have been evaluated individually in the courts. Most court evaluation of losses has been unsatisfactory to farmers. In many cases the court proceedings drag out for years and, in the meantime, agriculture disappears in the area. One location in the State of Washington has been cited which supported over 2,000 milk cows prior to the development of an industrial complex of aluminum plants and pulp mills. Many suits have been before the courts and during this time the number of cows in the area has been reduced to less than 100.

Farmers in such areas feel that they are constantly in danger of precedent-setting Federal court decisions which would give priority to industry over agriculture. Many times, representatives of the agricultural industry feel that they are discriminated against in the development of air pollution legislation. Such legislation sometimes considers the social and economic value of the air-pollution offender. This could be interpreted by the courts to mean that damage to farm property is acceptable if caused by an industry that makes a large enough contribution to the community—in other words, the larger the payroll, the more damage agriculture would be forced to accept.

Farm groups feel that the effects of pollution are not all of an economic nature and that economic losses are only a part of the entire problem. Farm families living in affected areas feel sure that many of the air pollutants have injurious effects on their health. To date, little positive knowledge is available on this very important aspect of air pollution. As a group, farmers desire to operate their business with little interference from external forces. They certainly desire to operate their farms without interference from injurious gases or dusts caused by other industries.

The agricultural industry realizes that it makes a contribution to certain phases of air pollution. Included is dust from unvegetated areas, especially during drought periods, also spraying programs and certain handling and processing of agricultural products. Agriculture feels that it has accepted its responsibility for contributing to air-pollution problems and that it is aggressively carrying on a program of corrective measures. For the most part, these measures are carried out cooperatively between individual farmers and local, State, and Federal Governments and certain industries.

The activities of individual farmers and local soil conservation districts, in cooperation with Federal and State conservation agencies, have done much to reduce soil blowing. Soil and water conservation districts now cover most of the agricultural counties in the Nation. Conservation measures on the land can be expected to increase for a number of reasons and, as a result, soil blowing will become only a minor nuisance.

Starting in the mid-40's, farmers have made extensive use of herbicides. Millions of pounds have been used on millions of acres from one end of the Nation to the other. Because of misuse of various chemicals, much air pollution has occurred. For the most part, damage has been to agricultural crops but was not entirely so confined. Crops seriously damaged include cotton, grapes, tomatoes, melons, sugar beets, alfalfa, and many flowering and ornamental plants. Much damage was done before farmers realized how volatile certain herbicides tended to be. Many State laws were passed to regulate the use of agricultural chemicals as the result of these damages. To reduce damages, farmers and chemical companies have worked cooperatively to produce new chemicals which would have the desired effects, yet not pollute the air. Pollution from this source has been greatly reduced with the introduction of new and improved herbicides and with a program of education among all users of chemicals, especially commercial applicators of herbicides.

Agriculture realizes that for the community, State, and Nation to experience continued progressive development, industrial, agricultural, and all other economic developments must exist side by side and that solutions must be found for their problems. This principle applies to air pollution just as much as to other mutual problems of competing groups.

Solutions to such problems will be found only as fast as public opinion forces various groups, private and public, to find adequate means of solving the problems. In order to inform the public of the severity of many problems relating to air pollution, there is necessity for a dynamic and aggressive educational program. Through the various educational media available in this country the general public must learn of the damaging effects of air pollution.

The fact that air pollution is a nationwide problem does not mean that the entire responsibility for an educational program should be assumed by the Federal Government. Such a program should be started in the local community by interested local people and their organizations. Many outlets are available in every community in the Nation for such programs. The State air-pollution organization and State colleges and universities should assume a great deal of leadership in assisting communities to carry out such educational programs. The Federal Government has a definite role to play by supplying factual data from adequate research programs.

Education should not be confined to informing the general public of the menaces of air pollution, but should also be designed to inform the contributors of the damages which they are causing in the communities, and of ways and means by which they may reduce pollution resulting from their operations. Much of this type of information will come from adequately developed research programs at State, national, and industrial levels.

The solutions to air-pollution problems are basically social and economic in nature. Society is now demanding and, with more knowledge of the damaging effects of air pollution, will more intensively demand, that air pollution be abated to the point where it does not adversely affect any segment of our society. The nature of our national society demands coexistence of many types of economic developments for the good of the Nation. These developments, which contribute damaging pollutants to the air, must and will assume their responsibility to society for the damage they cause.

The public must choose the type of social or legal structure through which air pollution will be held to a minimum. This choice seems to lie in four possible avenues. First is the voluntary approach, where all responsible for polluting the air individually assume the responsibility for control in the absence of any regulations. Second is compulsory regulation through the exercise of State police powers. A third alternative is control by Federal regulations. The fourth possibility, and one which organized agriculture would strongly support, would be control brought about by the cooperative efforts of the industries causing air pollution, a State regulatory organization, and the various research agencies. The Federal Government can make its greatest contribution through research, rather than regulation.

Many economic aspects of air pollution have to be considered in the development of any type of control program. Of first importance is the extent of decrease in goods and services resulting from pollution. If the decrease is sufficient to warrant a control program, what are the total costs of a satisfactory program for such items as capital, labor, and maintenance? What loss is industry suffering from not making use of certain byproducts which escape into the air as pollutants? How will payments by industry to those damaged compare to the costs of installing control measures? Whenever there are agricultural losses from air pollution, someone has to pay. Either the farmer absorbs the loss in his farm operation, industry pays for the loss directly or by installing adequate control measures, or the general public pays the bill. The only control program which can be justified is the program in which total benefits exceed total costs.

Serious air pollution is of relatively recent origin as it relates to agriculture in this country. However, it is an old story in many industrial areas of the world. Much progress has been made toward solving many phases of air pollution; however, the need for continued and increased research is extremely evident.

The increased severity of economic losses to the Nation from air pollution is well illustrated in California, where it is estimated that the visible injury to crops is annually over $6 million. This does not include economic losses due to reduced growth, reduced yield, and poor food quality, caused by continued exposure to contaminated air. Many scientists estimate that these types of losses are 5 to 10 times as great as visible losses to crops. Even these figures do not include damages to livestock, which are known to be extensive.

During 1956, court cases in the United States due to losses from the accumulation of one chemical—fluorine in livestock and crops—amounted to over $50 million. This is a problem involving many States of the Nation. It is more than a regional problem; it is a national problem. Fluorine causes the highest percentage of the total losses to agriculture.

The only research being done in this field is by various industrial concerns and several State agricultural colleges. No research agency or group of agencies is carrying on an adequate program to solve the many complicated and unknown problems arising from air being polluted by fluorine and other related chemicals.

For example it is known that humidity, precipitation, and prevailing winds all have an effect on fluorine damage. While this is known in general, little detailed knowledge is available. It is known that to control fluorosis the amount of fluorine being released into the air by industrial processes must be reduced to the point where foliage grown in the area will absorb not more than a safe level of fluorine. What is a safe level? Are tolerance levels the same for all animals? What is the exact mechanism by which fluorine and other air pollutants damage plants? To date, nothing has been found that will prevent the toxic effects of certain levels of fluorine in crops and livestock; this may be a possible control measure. Only research can produce the answer.

One of the real unknowns is man's tolerance to fluorine. It is thought that his tolerance is much lower than animals; however, the real answer is not known. Farmers living in areas polluted by fluorine are extremely interested in research in this field.

Air pollution from radioactive materials and their damage to plants, animals, and man opens an entirely new field—a field in which agriculture over the entire Nation has a tremendous interest.

Research facilities to cope with all phases of air pollution are totally inadequate. This is the field where the Federal Government can and should make a very real contribution.

Speaking of needed agricultural research, Charles B. Shuman, president of the American Farm Bureau Federation, wrote in a recent editorial, "The need is obvious—there are many doors that remain locked. Only a very material increase in the level of agricultural research will enable farmers to keep pace with the rapidly changing competitive economy in which we live . . . Yes. There can be plenty of money for a greatly expanded research program. Turning the keys in the locked doors to new knowledge is important to farmers and the entire Nation."

Mr. Shuman's quotation applies to research in air pollution, as well as to other phases of agricultural research. The Federal Government must make a real contribution to this phase of our agriculture program. The U.S. Department of Agriculture must assume an aggressive responsibility in this field of research. It has not assumed such a responsibility to date, but the time has come when the Department can no longer leave this important field of research entirely to industries and the State agricultural colleges.

Mr. Clayton. Referring to Mr. O'Harrow's comment on cleaning up industry completely, we should be thoroughly aware that it is impossible, literally impossible, to clean up an industry completely if that industry is of the manufacturing type. There is bound to be a certain amount of pollution coming out at all times. To what extent the amount of pollution should be allowed to exist is something that we should give serious consideration to, and that is where we need to have the knowledge.

In my job as a consultant, I have found that industry likes to be and wants to be a good neighbor and frequently the people in industry are very much surprised and chagrined that they are being accused of being bad neighbors, that they are insulting and assaulting their neighbor's property, that they are causing damage to vegetation. I have found that the reason that they are so surprised at being bad neighbors in the fact, literally, that they don't know the amount of material that is being emitted through their operations.

As planning officials, first of all we ought to consider what is the maximum allowable concentration that should be emitted from a stack in a particular location. Then the industry should be made aware that no more than that is allowed before they build a plant.

If they have these facts before them before they build the plant, they can do one of two things: Either they can put in the necessary controls or they can move into an area where they are allowed a greater emission than in this particular location. If we would request the Public Health Service to spend more time on developing maximum allowable concentrations, we would be doing a very great service to the repeal of air pollution in our country.

Mr. Dorn. I have passed out copies of a recent editorial in the *Los Angeles Examiner* under the title "Another Smog Source Gone." It is one of the finest editorials I have ever read. It tells the story of air pollution from a community standpoint and, more important, from the standpoint of an elected public official.

I think that we all agree that we have the problem. I was disappointed yesterday in being asked by one of the speakers to look back 50 years ago because I wasn't even conceived 50 years ago, and I know in the community where I was born, which is Pasadena, Calif., the fragrant emission in the air at that time was orange blossoms.

I like this editorial because it talks about our Government's policy of being responsive to the needs of our people and eliminating all known sources of air pollution. I was so pleased to hear the remarks this morning from Miss Butler, and believe me, the ladies of our community, the press of our community, the radio and television, and also the scientists of our community, have helped to do what has been done in our area in air-pollution programs, in air-pollution control. I think perhaps, quoting Congressman Fountain, who was Chairman of the hearing on the situation in Los Angeles last spring, "The Los Angeles County Air Pollution Control District is the strictest, most advanced control area of any place in the world."

This progress that we have made has been made through cooperation. I mean cooperation at each level of government, as we have exemplified here, where you have the Federal, the State, the county, and the city governments working together, and cooperation among the people of our community. This, of course, includes the housewives. It includes the breadwinners and, more importantly, it includes the industrialists and those men who are responsible for the economy of our community.

The third thing that we did there was to adopt a rule demanding the abolishment of backyard incinerators. I am told this hasn't been done any place else in California yet, but that this is a step that will be carried out in other parts of California.

When this was done, it was a direct attack upon the householder. This was a responsibility that was given to the homeowner, the taxpayer, the householder. They were being blamed for air pollution through this source and in a magnificient way the householder responded. This was over a year ago. It was accepted in wonderful fashion and there was a sacrifice of a $48 million industry. The industry making backyard incinerators was completely wiped out.

There was a sacrifice of over $25 million each year by the householders in securing other means of disposing of their combustibles. It was a wonderful effort on the part of the people of our community. The main reason that this was done was because we have adopted a policy of eliminating all known sources, regardless of who makes them and what the effect is upon the economy of our community.

Our belief is that public health and welfare are of the most importance. This is the primary concern that we, as we carry out our program in Los Angeles County, are concerned with.

Just last week, prior to my coming here, we adopted a rule which will ban the use of fuel oil.

Here was an example of restricting an industry in our community, and I mean a very large industry, the petroleum industry.

The Western Oil and Gas Association, which represents all of the oil industry in our area, was very upset about this rule that we had proposed and we went through 6 weeks of the most unheard of and uncalled for kind of pressure that you can imagine, trying to keep us, the elected officials who were responsible for the control of air pollutants, from passing this rule. Again the *Examiner* in Los Angeles came out with a front page editorial. It is entitled "Smog Pressure," and this tells about the responsibilities of industry and the cooperation needed between industry and the people through its elected representatives.

These two editorials are fine examples of the kind of cooperation that we need. This is a cooperative effort. We are not ever going to control air pollutants in any area by playing one source against the other. You are not going to control this problem with attitudes like that of the auto industry, who will come to this conference and tell you about what happened 50 years ago. We are not here to talk about what happened 50 years ago; rather, we are here to talk about what can we do now, what can we all do working together to solve this problem in the interest of the health of our people.

To say that the man or woman who owns and operates an automobile is now the responsible agent in this problem is begging the question.

If his automobile did not pollute the air when the buyer bought it, I would agree that perhaps the misuse of that vehicle was important, but all of our scientists, all of our staff reports indicate that the automobile when it is first sold, when it comes off the line, is a major contributor to our problem. Therefore, how can anyone possibly say that the misuse by automobile owners is the big problem?

We must get down to the facts and the basic facts are that in our county, at least, we have reduced the pollutants that we can by controls, that through our scientists and our engineers, we have perfected. We have one major remaining source and that is the exhaust from motor vehicles and it is about time that we talk about the industry's responsibility to the public health in our community from this source. I don't want the blame shifted to those people who might misuse or operate that motor vehicle.

Mr. Ledermann. I would be interested in having some differentiation made at this conference between the immediate local or perhaps regional types of pollution such as the familiar smog in Los Angeles and the obvious heavier concentration of pollutants in your urban areas at a particular time and place—the Donora sort of thing or on a lesser scale—and then contrast both with what I think must be the long-range increasing saturation of the atmosphere as new sources of pollution are added all the time. And here I go back to the point that Mr. O'Harrow made about the population of the United States quite possibly reaching a level of 1 billion by the year 2050, in something less than a hundred years, if the present net birth rate continues. That is literally an astounding figure.

How could we ever get to that enormous population figure? That is almost a half of the total world population at this time. Well, the Census Bureau recently released its official forecast of population growth in this country through 1980, which is just 22 years away, and their forecast at that time—traditionally on the low side—is for the U.S. population in 1980 to be 272 million. The population recently passed the 175 million mark.

That means that in the next 22 years, roughly, we can expect a 100 million increase in population in this country. So obviously these rates of increase are far in excess of what we have been experiencing in the past and at that rate I think that the problems of general chaos, of which air pollution will be just one of the many problems, certainly can increase to the point where our past wrestling with these problems has been merely preliminary. The scope of the problem in the future, in the immediate future, may be considerably greater than we have been prepared to think.

Mr. Mason. We in the Federal Housing Administration are vitally interested in this problem of air pollution, particularly as to how it affects property values. Our business is in the insuring of loans on homes and apartment houses. We assist in the financing of from 20 to 25 percent of the new construction in the United States every year. We are a self-supporting agency. We live on the income of the insurance premiums that we charge. We have to operate as a business organization. Therefore, it is vitally important for us to measure very carefully the risk involved in each mortgage insurance case.

The problem of smoke or noxious odors is very often the cause of rejection of an application. So this is a very interesting conference to us.

Today we often hear of, on the one hand, the flight to the suburbs and, on the other hand, we are increasingly hearing about the rebuilding of the American city, often referred to as the urban renewal program. FHA, of course, participates heavily in both. In the suburban areas we often see satellite communties growing up around some big, fine, modern factory building. Here, as was pointed out this morning, the smoke emissions, the noxious odors, and so on, have been brought into control by modern methods and, far from being a detriment to the community, that factory building is really the very heart and life of such a community. In this case the factory is actually bolstering up property values.

We are also interested in our mortgage-insurance program in urban renewal, this relatively new approach to rebuilding the American city. There we have urban renewal plans developed by a city to take out, excise, a slum area in the heart of the city. This is usually the oldest part of the city; it is usually affected by industry, and here we have the problem of cleaning up industry, applying smoke-control regulations and modern techniques. These things, as practiced today, make it possible for FHA to insure loans on new residential structures in these parts of the city. So control of smoke and noxious odors in areas both outside and inside cities is of vital interest to FHA and their proper control is what makes it possible for us to give the benefits of our mortgage-insurance program to individual homeowners.

Mr. Merrill. So many questions have been raised that I will limit my discussion to one thing, the corporate image that we seem to have. Mr. Dorn showed that the homemaker will cooperate, if he is given the opportunity, and stop burning rubbish. Industry will, too, under one condition.

I was rather amused that a couple of the speakers referred to modern industry as being clean. They have their smoke-control devices and everything. Another speaker mentioned that the brand new aluminum industry managed to decimate the bovine population in the northwest.

It all depends on what kind of industry you are dealing with. The metallurgical industry is going to be dirty, usually, and the electronics industry is nice and clean, and that is the kind that usually settles in a residential district.

To get back to the corporate image, nobody is going to put in any kind of control devices that costs him money unless he has to, and that brings up the question of sanctions. There must be sanctions against industry or else it is going to pollute the air. These sanctions can be of many types. It simply has to be unprofitable for an industry to pollute the air or else they are going to pollute it, because it is cheaper to use the air as a sewer than to pay for keeping it clean.

I was impressed today with the number of weapons that this group seems to have been able to assemble, and we saw that we can get public pressure from the women. The unions can exert pressure, too, because they have to live near the plants, but I think that eventually regulation is necessary.

There is a tendency to look at regulations and say, well, let's set a maximum quantity that companies can let loose. I don't think that is the right way to do it. The objective through public pressure should be to get rid of it all. Maybe it can't be done. I don't think it is proper to say that we are going to limit the air pollution to a certain amount with precipators and new devices coming in if there is a possibility of eliminating all of it, although full facilities may not be available now. In 10 or 20 years, if the pressure keeps on, we will find in this area of technology, as in every other, that we go beyond what we know today and can go below any presently established minimum.

Today there seems to be resistance to Government regulation. Yet perhaps that is the only way to do it because our country is changing so fast. We have one city now from Augusta, Maine, to Cape Hatteras. It crosses State-city lines. There is no other possible way, in my opinion, to regulate that big a geographical area except by Federal regulation.

QUESTIONS FROM THE FLOOR

A. N. HELLER. Don't you think, Mr. O'Harrow, that emphasis on "poisoning" an area arouses an emotional response which tends to preclude a rational, cooperative approach to solving the air pollution problem? Second, in your opinion, how much has the industrial community spent in the past 5 years to solve this air-pollution problem?

Mr. O'HARROW. As to whether the word "poison" arouses an emotional reaction, as a hidden persuader or something like that, I am sure that it does, but I think that the use of hidden persuaders cannot necessarily be preempted by private industry and the advertising people. However, if carbon monoxide is not poison, will somebody please tell me what a more acceptable term is for it? And there are some others, too. Maybe some chemist will correct me on this, but someone told me that actually hydrogen sulfide, that horrible-smelling thing, is even more poisonous than carbon monoxide.

As for the second question on how much the industrial community has spent in the past 5 years to solve air-pollution problems, my answer to that would be just a guess. But I heard yesterday that the automotive industry is now spending $1 million a year, maybe about half the cost of one of its 15-minute programs on TV.

I am sure that there are a lot of industries spending a lot of money, and I was certainly impressed by the sincerity of some of the expositions yesterday on what the industries are doing. I think that obviously the steel industry is spending enormous amounts of money and has accepted quite a sense of responsibility on this. The chemical industry has, too. I even was surprised to find that the petroleum industry is doing the same.

I would say the automotive industry exhibits the most immature, the most petulant attitude, if their attitude is as given yesterday, of any industry that I have ever known.

ROBERT PERMAN. What would be the probable effect of developing and adopting air-pollution industrial standards as a tool for planners and zoners in terms of affecting community development and community values, and as an incentive to industry to clean up if it wants to locate in a desirable area?

Mr. O'HARROW. First, as to the effect on community development of the community adopting air-pollution standards and other standards on noise and, say, stream pollution, land pollution, and some of those things, it is my experience that the good industry likes to go into a community which has strong, well stated standards on development, on zoning, on planning, and things like that and that it prefers not to go into a community which does not seem to have enough sense of community responsibility and community respectability to try to put these standards in.

That is for the "good" industries. There are obviously some less than good industries who are trying to get into areas where there are not controls because they don't want to abide by any controls. So I think that on the whole good, logical, reasonable standards, well and honestly administered, will attract industry to your community—good industry—and won't attract the fly-by-nights.

Second, there is a great deal of incentive for industry to clean up if it wants to locate in a desirable area because the area is desirable for any of several reasons: It has the proper transportation, the proper market, the proper labor force; the raw materials are available; it has a certain eye appeal. Obviously, part of this whole business of cleaning up factories is a public relations or community relations job of making the factory pleasant and pretty to look at, and it helps to sell the product. So I am not quite as pessimistic as Mr. Merrill about industries not cleaning up unless it is profitable to clean up.

Profit comes in many ways, and it also comes by being acceptable and liked in a community. This is something that perhaps you can't put a dollars-and-cents value on, but it is the kind of profit you get with good will, or something like that. So I think that there is an incentive to be located in an area that has good, reasonable standards, well administered.

ROBERT M. MAHONEY. In relation to Miss Gifford's plea that the women of America be better informed regarding air pollution, what is your reaction, Miss Butler, to the idea of your organization giving widespread publicity to the fact that two-thirds of air pollution is attributed to highway traffic?

Miss BUTLER. To Mr. Mahoney, and to the rest of you, I would say that the women of America probably drive cars as much as men, and so it is their own problem, too. It is a problem of the people, and I believe that they will be very grateful for the facts and will work for any program which will reduce the waste that makes the atmosphere unpleasant and unsafe.

As to our organization getting behind this publicity, suppose I give you a statement on some legislation that just went through. We are not fighting altogether for legislation. If it is necessary, we will. But if we can do it through study programs, and so forth, we will do that. With regard to a certain bit of legislation that passed in the 85th Congress, they said the pressure and the mail that came to Congress from women of this country outdid anything that they had ever had on any piece of legislation. So I think that there is no doubt in the world of the effectiveness of women working for something that may be good for the family.

Mr. MAHONEY. In relation to community development and property values, Mr. O'Harrow, what is your reaction to urban industrial districts zoned and located to minimize air-pollution problems?

Mr. O'HARROW. You mean the planned industrial park, planned industrial district? For the most part this is the coming way of industrial development throughout the country. There is no doubt that this is most efficient way of developing industry in our country, instead of scattering it here and there, instead of getting this mixture, the mixture that caused slums, which was a mixture of industry and residences all jumbled up together.

It also had the opposite reaction of creating a slummy kind of industry. You can't mix them without both sides suffering, and the planned industrial district is now an integrated industrial complex in which you can control things more definitely, and it is obviously the coming way to handle industrial development. I am all in favor of it.

Mr. Mahoney. Would economic research seem worth while, Mr. Butler, to determine the relative losses from (1) air pollution, (2) water pollution, (3) climatic variations, (4) soil erosion, and (5) soil depletion?

Mr. Butler. The person who asked this question must have noticed that I have devoted some of my life to conservation. Before you can put a value on any of these, we have to have economic research, and certainly in air pollution. The total benefits have to exceed the total costs. Certainly, there has to be an economic study. Certainly, the same thing applies to water pollution.

I am not sure what the questioner has in mind as to climatic variations. But as to soil erosion or soil depletion, we always have to consider the economic phase of it. The farmers will do something about these things when they can economically afford to do it, and certainly we need many studies in this entire field.

Soil depletion is beginning to show up more and more. I come from an area in Minnesota where the farmers, just in very recent years, have found that they have to add fertilizers. They have been cropping their land without fertilizers and doing very well. The farmers were told this cannot go on, and now we are at the place in this particular community where we know this is true. I would say we must have economic research in all these fields to properly evaluate them.

Mr. Heller. Miss Butler, how can industry tell its story more effectively so that the women of America can understand how much has already been accomplished and how much is now being expended to solve the problem?

Miss Butler. If such industries would supply brochures, material that is factual about the subject so far as their industry is concerned, give them statistics—women know something about statistics, too—give them the facts and let them know, I assure you the women will be on your side. If you are really doing something, they are going to give you credit. They may keep pushing you to do more, but nevertheless they will not just come out and say you are doing nothing.

Unidentified. In the design of buildings and selection of materials, what can architects do to reduce air pollution and mitigate its effects? What can be done by homeowners?

Mr. Mason. This is not really a problem for architects; this is a problem for planners. There is nothing you can do in designing a home that would completely isolate that home from the outside atmosphere. You cannot hermetically seal up a home. It is true that we have air-conditioning devices in our heating and cooling systems that help in this respect, but you cannot completely cope with the problem in this way. Again the responsibility comes back to being one of community responsibility and industry responsibility and it must be dealt with basically that way. Air-cleaning and air-conditioning equipment can help, but the basic thing lies with the community.

Miss Butler. As for the homeowners, the women will buy the equipment that serves best, and the better you make your equipment for the purpose the more business you will have out of homeowners. The housewife is going to use the best she can get.

D. H. Sloan, Jr. Suppose an industry is polluting the air in a community and that it is a necessary industry and would be forced to close if it had to bear the expense of freeing the air from pollution. How far should the community go in taking care of this expense?

Mr. O'Harrow. Any answer to this is going to be hypothetical. At present, if industry is polluting the air in a community, of course, the first thing that you try to persuade them to do is clean up. Then, if you can't persuade them, you try to force them to clean up. If forcing them into cleaning up means they are going to have to shut down, then I think it is possible—so far as I know, it has never been done yet—that you have two powers you can operate under. One is the police power, in which you say that the benefits to the health, welfare, morale, and so forth, of the community far exceed the damage done to the industry, to the individual owners of the factory, and therefore if they can't clean up, they shut up, and you shut them up.

The other governmental power you can work under is the power of eminent domain, and you say that the benefit to the community from closing up this plant is considerably in excess of the cost of buying the plant to shut it up, and so you condemn it and use the power of eminent domain to buy it, pay a fair price for it, and close it up.

So far as I know, that latter method has never been used, but it seems to me that eminent domain must be operable for a public purpose. That is the catch phrase in this, and it seems to me that it would not be at all difficult to show that the closing of a factory to eliminate the pollutants it was putting into the air is a public purpose and is a proper way of spending public funds through the power of eminent domain.

Unidentified. What is FHA's position in insuring redevelopment financing (1) if the abolished combustible property is to be burned on or off site; (2) if burning is prohibited?

Mr. Mason. To answer that, I first would like to explain how the urban renewal process is administered. First, there is generally an agency of city government known as the redevelopment authority or redevelopment agency, urban renewal administration, or something of that nature. It is a local agency set up for purposes of carrying out redevelopment projects. We in FHA do not have any jurisdiction over these people. We work with them and try to assist them, but we have no jurisdiction over them.

Second, there is an Urban Renewal Administration, which is another agency of housing, which grants Federal money to these local redevelopment agencies.

The question you asked comes properly within the relationship of the local agency and the Federal Urban Renewal Administration. This matter of how a project is made ready for development comes within the scope of the urban renewal plan, and that is under the jurisdiction of the local agency and the Federal Urban Renewal Administration.

We in FHA collaborate with these people to some extent during the planning period, but we in no sense control them and do not dictate policy to them. It is after the area has been cleared of the slum housing and is made ready for redevelopment and sale to individual developers that FHA comes into the picture. It then offers assistance through its mortgage insurance on loans made by private lenders to the redeveloper, who is putting up the new housing construction. So we in FHA would not control the situation described in this question.

FRANCIS DUNN. Do you think the auto industry could discharge its obligation by having its product plainly labeled "Poison" as many producers of explosives and dangerous articles are required to do by law?

Mr. DORN. Pollutants start coming from automobiles when they are right off the assembly line, and they should not, in my opinion, come off that line without some proper control. If the makers will not provide that control we may have to ask them to label their cars "Poisonous." I hope we don't have to. Our objective, of course, is a crash program to provide our community with a healthy car instead of a bigger, more beautiful, or more powerful car.

Dr. BARTHEL. This next question is unsigned, but I suspect it is from one of the organizing group because it is a question that I myself would like to ask.

(1) What are some of the specific economic problems of air pollution to a community? Please cite cases; that is, if some of the generalities mentioned could be put on a specific basis.

(2) What are the costs of air-pollution effects to a community on a monetary basis?

(3) Are we arbitrarily placing culpability upon air pollution for certain effects when such blame cannot be proven?

Mr. MASON. One of the urban renewal projects that we assisted in FHA is located in Cleveland. The site was bordering the industrial valley of Cleveland. It was an old familiar type of rundown slum described earlier here, and some undeveloped land that lay undeveloped because there was nothing further that could be done with it.

The city at the same time having pressing need for housing for its workers, particularly a minority group, the plan for this area was drawn, an urban renewal plan, that is, in the early part of 1955, involving filling in a portion of a large valley, the demolition of a good deal of slum area, the rehabilitation of a part of the slum area that wasn't so far gone that it could not be salvaged—all this under one plan. The plan called for replacing the old housing with new public housing, some 1,200 units of it, and new privately financed housing, some 450 units, the latter to enjoy the benefits of FHA mortgage insurance.

Looking at a project like that, we in FHA are quite concerned with the risk factors. We just do not go in and insure loans indiscriminately, without taking into consideration the harmful factors, experimental factors which might cause ultimate defaults and loss to the Federal Housing Administration. We have to take all these things into consideration.

Now, one of the many things that was of grave concern to us was this matter of smoke, noxious odors, fallouts from the industrial valley on which this site bordered. I was quite interested in hearing the steps that the city government had taken to control this problem: the systematic testing of fallout, the requirement on the steel industry there to install equipment and devices which would minimize to a great extent the fallout and smoke. The progress that had been made there, the very fine progress in this control program, was one of the factors that made it possible for us to go into this program and insure loans on some 450 units of privately developed housing.

We have many more projects of this same type that are going forward in various cities throughout the United States where similar problems exist.

Mr. Dorn. In the city of Pasadena, we revised our zoning code merely by adding a new section headed "Prohibited Uses of Land in the City of Pasadena," and we listed 45 such prohibited uses of land.

This was thought to be a very drastic and emotional expression by the elected officials of our city. It was going to ruin the economy of our city. But because of this proper planning, our city's industrial economy is at least 10 times greater than it was prior to this planning program that we enforced through our zoning code.

There is also one specific figure I would like to give. It has to do with the auto industry and its part in cooperating to combat and eliminate air pollution. I have before me the net sales as of December 31, 1957, a figure which indicates how much the public spent across the nation on automobiles—$20,901,500,000. This includes American Motors, Chrysler, Ford, General Motors, Studebaker, and Packard. It seems to me that when the public is spending $20 billion a year for automobiles, it is hardly more than a token contribution for this industry to put a million dollars a year into research on this very serious problem. I think their responsibility is much greater.

Mrs. E. N. Lightfoot. What can we women do, Mr. Dorn, to get the auto manufacturers to make a car that is clean? We will buy such a car.

Mr. Dorn. About 6 months ago, we ordered the air-pollution-control district in our county to test in our laboratories all of the makes and models of automobiles manufactured here in America to determine which of these makes and models contributed least to the air-pollution problem. We felt that was our public responsibility as elected officials. When these results are known, we in our county will specify that make and that model of automobile when we buy the 4,000 cars that we buy for our fleet each year, and I think our example will be a very fine one for the ladies to follow.

Hugh A. Johnson. Is there a representative of the auto industry in the house? What is the status of research on the design of more efficient motors, burners, waste disposals, or whatever is needed? Any estimate on probable added cost of an auto to have such a gadget when it is developed?

Oliver P. Baker. I am from the Automobile Manufacturers Association, and I have been somewhat shocked at the attitude that has been taken this morning toward this question of expenditures of $5 million a year by the automobile industry.

Mr. Dunn. One million.

Mr. Baker. I beg your pardon: 5 million during the past 5 years.

The question was asked if there was a representative of the auto industry in the house. I can't help but think that many of you people have become confused between research and production engineering. If we had a device that would eliminate all of the pollutants from an automobile, we could put millions of dollars into it and produce it and put it on cars, but we have been asked to find out how to develop such a device.

One of the first things we had to do about 5 years ago was to get into the problem of developing instrumentation to measure pollutants in the nature of a few parts per million or a few parts per hundred million. We were asked to do a lot of these things all at once. We were asked to develop devices; we were asked to do research. Actually, we were somewhat limited in the number of qualified people. Many people seem to think that just because a billion dollars was poured into the development of an atomic bomb you can do the same thing in engineering any other product, but you forget the fact that about 45 years of basic fundamental research preceded that.

We have been asked to do the basic, fundamental research job on this air-pollution problem as far as the automobile industry is concerned, and I feel, and I think the industry does, too, that the million dollars a year spent in money and personnel was about the maximum that was possible in the light of the present state of knowledge in the field.

Dr. Barthel. Any estimate on probable added cost of an auto to have such a gadget when it is developed? I presume that Mr. Baker means from his statements that the state of the art is such that it is impossible to estimate the cost of such a gadget at this phase.

Mr. Baker. That is right.

Dr. Barthel. Any rebuttal?

Mr. Dunn. What is bothering me is this paragraph in Mr. Williams' speech of yesterday:

"What I want to discuss today is something which, so far as I know, no other industry has ever been called upon to do: namely, to concern itself with how the consumer uses or misuses the product long after its sale to the public."

That seems nothing less than the disavowal of responsibility for automobile-exhaust problems which come from the factory.

Mr. Dorn pointed out those problems should be licked, if they can be licked, before the car gets off the assembly line. I recognize that, although they receive $21 billion a year in net sales or spend hundreds of millions for television and other forms of advertising, if it only takes a million a year for research and development, that is all that should be spent. I don't think the million dollars is related to the $21 billion; except that if they could spend more than a million and do the job quicker, they should do it. I resent the disavowal of responsibility and I am not at all sure that their collaboration in the development of control devices is not something of a collaboration of "don't you improve your auto exhaust until we are all ready to do it at the same time," in order to circumvent the very thing that Mr. Dorn pointed out. That was that if one company developed a device and marketed that device, even if they had to leave off one tail fin in order to keep the price down, then the other companies would eventually be boycotted by those who feel it is more important to have a healthy, safe car than a fancy car.

Dr. Barthel. I think it has been fairly well brought out by a number of speakers that any real progress in the area which we are discussing today must be brought out with the cooperative effort of all parties involved.

I have just lived through a very pleasant experience in Chicago in which we made a draft of a new air-pollution-control ordinance. Ours was woefully outmoded and outdated, and the cooperation of industry was superb. They contributed heavily in manpower and assisted in research of all types in getting this chore done. The city would have never done it without the cooperation of big industry, and I am sure that this is what we are shooting for in all aspects of the air-pollution problem.

Mrs. Andrew Parker. Mr. Ledermann, do you foresee any broad use of solar energy in homes of the future? If so, would not this help diminish one source of pollution?

Mr. Ledermann. I will disqualify myself as a technical expert on the matter of home construction, but from what I do understand, solar heating and the use of solar instruments in connection with housing is definitely increasing. I think, though, that as a practical matter, in contributing to the decline of the air pollution problem, this is not in a state at the present time where it is of enough importance to be regarded as a frontline attack on the problem. I think that that must come from another direction.

Dr. Barthel. Any further remarks from the panel?

Mr. Merrill. When I said that industry had to be hit in the pocketbook before it changes, that is a shorthand way of saying that not all companies are looking at profit in the broader sense, although many are planning for 10 and 20 years and not just looking at the day-to-day return. I was thinking in terms of putting a sanction on which says you are going to be fined $15,000 next month unless you clean up. I don't think that is any attack, but I do think that industry has to be told that for the long stretch they are going to be forced to clean up.

It is obvious from this meeting in these 3 days that it is in the cards, and it is certainly going to hit them in the pocketbook if they have to close their plants. But it is a case of getting ready. The more progressive companies already have created a proper image of themselves in this progressive cleaning up. The ones that haven't are going to have to catch up.

Mr. Dorn. I feel that all in government, staff people as well as elected officials, have a responsibility to industry. I don't think it is fair ever to encourage industries to locate within your community without their full knowledge of all of the rules and regulations and requirements that they are going to have to abide by. That is one of the reasons why, under our air-pollution-control district, our planning commission, we have for the past 2 years been studying a zoning plan which would set up areas within our county wherein industries may be placed. We want to have a complete zoning master plan which provides for all the necessary segments of our economy. This is fair to industry people because it shows them where they may locate an oil refinery, an auto manufacturing plant, a steel manufacturing plant, or some other industrial plant.

We in government should never encourage or promote their coming to our area without a two-way-street situation wherein they know full well what the requirements are. It is not right to have them establish a $20 million plant and then tell them you should have done this and we are going to make you do that. This is wrong, and every single industry that comes to our county has to get a permit to build and to operate within our county from our air-pollution hearing board, and we process 300 such plans every month. I think this is our obligation to industry, and this we do.

Dr. Barthel. Does anybody have any specifics in answer to this general question that we read a while ago: What are some of the specific economic problems of air pollution to a community? Please cite cases. What are the costs of air-pollution effects to a community on a monetary basis? Are we placing culpability upon air pollution for certain effects arbitrarily when such blame cannot be proven?

Mr. BUTLER. I would like to cite one example, and I think all these questions tie into it. In a valley in the West, a relatively narrow valley, a manufacturing concern came in and located. This was probably such a rural area there was no such thing as a permit that had anything to do with air pollution, which they had to get before they located there. It was evident within a very short time that a great deal of fluorine was being thrown into the air. It was evident in a very short time that this was affecting the crops and livestock in that area. About a year ago there were suits before the court, as I understand it, asking for $30 million worth of damage, and there was no doubt where the pollution was coming from. It had to come from this one plant. It was the only plant in the area.

The industry is going a long way. It is going probably as far as its people think they can economically. They have gone a long way to carry on research and to get their plant in as good a shape as possible.

This plant happens to be located in Utah. I understand that Dr. Greenwood is in the audience. If he is, I would like him to make some further comments on this.

Dr. D. A. GREENWOOD. That particular industry became aware of what the situation was, and on its own put in machinery to clean it up. Let's go back and say the U.S. Government put up the plant to begin with. So that the people putting up the plant—it was a war plant—didn't pay too much attention to air pollution in its original plant. So this was really a Government responsibility before this industry was involved, but when the industry did become aware of the problem, it did set up machinery for first ascertaining the facts. They also provided forms for the farmers in the area and helped them to fill them out. Eight hundred and eighty-nine farmers were paid something like $4½ million. The company plus the farmers sat down and worked it out. Then you had some farmers many miles away that wanted to get on the payroll of the industry. This is where the problem came in, where the big losses come.

It was brought out by Dr. Gustavson yesterday that many of the necessary basic facts are available; sometimes people use them and sometimes they don't. But if we are going to have good development of our country based on information regarding concentration of all of the pollutants and how they affect man and animals, planning officials and industrial officials and all must know what these facts are. Then, once you know what the situation is in an area, if a new company is coming in, it is possible for it to decide if the SO_2 load is such and the hydrocarbon load is such, and you can deal with them in the planning stage. The dislocations that come as a result of losses is not in the national interest, and the only way it can be corrected is for more intelligent planning, with more information available to enable everybody concerned to make intelligent decisions.

Dr. RAYMOND MANGANELLI. This last series of questions was mine. I don't want to put the blame on any of the organizers. The reason I asked for very specific data is to remind your panel of what it is supposed to do. We start talking in generalities here. We are all against sin and for God, mother, and country, and then we assume that all the blame goes to air pollution. So I think that when you have your evening session this evening, and think of the damage to materials and substances and property, you should assess what damages you can really pinpoint that are being done by pollutants.

As to monetary estimates, I realize that estimates have been made at $10 per person per year, but that went back to 1947 and was just taken up and carried on. Somebody has now prorated it up to $65 or something of that sort. So now we may be just carrying on with this figure. These are some of the things I think the panel should concern itself with.

Mr. CLAYTON. Let's get down to the basic facts. What is air pollution? Pure air actually is just a laboratory curiosity. There is no such thing as pure air on the surface of the earth. So the question is how much air pollution do we want to tolerate. That is a matter in which each individual, each community, as I see it, must answer to its own satisfaction.

I feel that right now nobody has scientific data to base their thoughts on how much air pollution we want to tolerate.

I would like to see, essentially, a curve—to put it down in the simplest form—a curve where we would have cost of air-pollution control versus the amount of clean air we want. If we are living in a community and we feel that we want the cleanest air possible, then we could look on this graph and then indicate how much it is going to cost us. On the other hand, if we want to live in a relatively dirty area, we could do so and the cost would be a certain amount.

I would like to see this curve based upon such factors as health. It is a sad commentary, with all the millions of dollars being spent on air pollution today, that we still do not know what caused the Donora disaster. We do not know how much pollution can be accumulated in Los Angeles County, in the basin there, before people start dying. They have an alert system, as you all know, and it is based upon the best estimates that the authorities can give them, but I have never seen any scientific data that would indicate that when the concentration reaches a certain point those people with certain diseases are going to die. That is the type of information we should get out. It should be on this curve.

Another phase of it would be the economic problem. How long will our paint last under different conditions of air pollution? In other words, do we want to have to paint our house every year or would we like to keep the paint on the house for ten years?

You can do any of these things if you want to pay the price, and I think that what we need most of all are facts on which to base our conclusions and I would like to see coming out of this committee recommendations. We are instructed to present recommendations to the Public Health Service and I would like to see that we recommend to the Public Health Service that they do research along the lines that I have just discussed.

First of all, there has been talk from time to time of the Public Health Service going into the field of controls. In other words, having laws. I personally feel that this is a very serious mistake. And I don't think the Public Health Service should have laws on the books to enforce because I don't think they could enforce them. The Public Health Service is not an enforcement agency.

Mr. Dunn. I would be sorry to see this panel get too far away from our own part of the subject. There is a panel discussion on the health effects of air pollution. There is another panel on the extent of air pollution, which I suppose would say how clean we want the air, how dirty it can get. I differ to this extent with Mr. Clayton: while all are eventually difficult ones, there are other impacts on health besides actually dying. We get probably seventy to a hundred colds in the course of a lifetime. We get bitten by mosquitoes; you are plagued with all kinds of vermin of one sort or another; and we get many kinds of diseases; but we die only once. I don't think we should recognize the impact of air pollution only on the mortality rate—the point where people actually die—before we do anything about it.

What we ought to talk about here is the kind of thing Miss Butler talked about this morning, the social and economic impact of air pollution, like how much money you spend on detergents. As a house painter by trade, I would like to see you control all of those factors that cause annoyance, et cetera—those, for instance, which make you paint your house a little oftener. To me as a painter, that is an economic aspect.

Mr. Mahoney. I am here as representative of the American Institute of Mining, Metallurgical, and Petroleum Engineers, a constituent society of Engineers Joint Council, a group of 250,000 professional engineers.

I want to compliment Mr. Clayton on his remarks about positive recommendations for the future. I can do this best by quoting one basic principle which we professional engineers—as engineers, and not as members of trade associations—think is quite relevant to this problem. One of the principles incorporated in a policy statement of the Engineers Joint Council just about a year ago reads like this:

> Air pollution and its control involve many scientific problems that have not yet been solved. There is no simple or quick answer. Continued research in this field is vitally necessary. The engineering profession has the obligation of reaching the best engineering solutions to these problems.

We recognize that we can make but one contribution to a field that requires contributions from many, and on this point I make my second comment.

Our organization is very cognizant of the cooperation necessary to accomplish the objectives that are being stressed in this session and others. From the engineering viewpoint we would urge consideration of this principle in the report of your group:

> Engineers are involved, through research, development, design, construction, installation, operation and maintenance, in activities that bring into being man-made sources of air pollution. Engineers have already made substantial contributions to the solution of air pollution problems by application of technical knowledge. Many of these contributions have resulted from efforts to utilize fuels and raw materials more effectively, while others have come from efforts specifically directed to minimizing air pollution nuisances and hazards.
>
> Other professional disciplines are contributing to effective air pollution control in many fields; including agriculture, biology, government service, law medicine, meteorology, politics, public health, science, and soil conservation.
>
> The engineering profession is prepared to discharge its responsibilities in the physical control of air pollution by full participation with other professional disciplines, in establishing and effecting sound policies of control.

This is our offer as a large group of professional engineers to accept our part of the social responsibility for air pollution.

Dr. BARTHEL. I have asked our vice chairman, Mr. Crago, to summarize briefly our discussion of this morning.

Mr. CRAGO. To start with, Dr. Barthel said that we have been charged to face our problems honestly and realistically.

Mr. O'Harrow, in his talk on industrial and community development and property values, helped us appreciate another complexity of our subject. He emphasized that old industry was quite often dirty industry and brought on slums. He warned that even the new, the cleaner, industry can equal the old in total air pollution if it expands as fast as it seems likely to.

Miss Gifford's paper stressed the need for education, on the part of the housewife, about the menace of air pollution and the possibilities for its control.

Mr. Butler covered agricultural considerations. He spoke of extensive losses to agriculture due to air pollution and called for more research to find out what air-pollution level is harmful and how much can be tolerated.

To "face our problems honestly and realistically," some of our discussions got just a little bit warm, those on the automobile industry, for example. Quite often, however, when you feel that a particular industry may not be cooperating much, if you walk into the boss man's place of business and tell him he is a bad citizen, you find that that is news to him. He has been operating in that place for quite a while and feels that he has always been a good citizen. He is a leader in his community, maybe. It takes a little educating to show that man just where he is a bad citizen, and I think that when it is pointed out properly, he will recognize the facts and make changes accordingly.

If we do face our problems "honestly and realistically," we will come to the conclusion that in each community everybody is guilty of air pollution and that today, when we correct this problem, it may hurt me; when we correct that other problem tomorrow, it will hurt you. I think we need to have education in the community that gives people a general picture of the whole business so that we can use good judgment in making up our minds what kind of air we do want, what kind of air we must have, and what kind of air we can afford.

Mr. DORN. In answer to one of Miss Butler's questions—what can we do to resolve this problem?—in my opinion the best thing we can do is to take part as often as possible in this kind of a meeting. If we will work constructively together—Federal, State, and local government representatives, service and civic organizations, and more importantly, just people—we are going to solve this problem. We are not going to solve it if each of us, with our own special interests, attacks the other as being the main source of air pollution. It is a complex community problem involving all of us. That is why I hope that tomorrow, when your chairman reports to the general session, there will be a call for another meeting involving these same individuals and organizations to review and implement what has been done at this meeting.

In October of 1957 I wrote to President Eisenhower asking that this conference be held at a national level. This was referred to the former Secretary, Mr. Folsom, and then to the Surgeon General, Dr. Burney, and his staff, and out of this came our invitation to take part in this National Air Pollution Conference.

I think we should acknowledge the leadership given by Surgeon

General Burney, by Secretary Flemming, and even by the President, who actually gave, as the Surgeon General said, an added weight to this kind of a meeting.

I think this group should also go on record in favor of continuing the program that Senator Kuchel and many of his associates sponsored, known as the Air Pollution Control Act, wherein $5 million for 5 years was appropriated to be used in research and technical assistance in controlling air pollution. I hope that this program can be continued when it expires in July 1960, and that it can be expanded according to the needs brought out in meetings such as this.

Impact of Air Pollution Control Programs on Our Economics and Society (I)—Industrial Investments, Taxation, and Community Relations

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Air pollution has come of age! If proof were needed, the presence in Washington, D.C., this week of hundreds of persons busily engaged on some aspect of this problem would be proof enough. The public is aroused on this subject, that is clear. Industry is devoting vast effort and money to the problem. No longer is air pollution a problem the plant manager thinks about for a half-hour on Saturday mornings. It has become a task to which an entire department devotes its full time. A great number of people work full time in various governmental agencies on this problem, and almost every scientific society has a committee on air pollution. Meetings on this subject have become so frequent that one endeavoring to establish a record could, without difficulty, attend a meeting on this subject somewhere in the country at least once a week.

Air pollution does not define itself, and air pollution means different things to different people in different parts of the country. Los Angeles is principally concerned with eye irritation and reduced visibility, while St. Louis and Pittsburgh think of air pollution as meaning only smoke control. Of course everyone contributes to air pollution every day by smoking cigarettes, driving automobiles, burning trash, etc. All these sources send unnatural substances into the air. The kind of air pollution I am talking about is the presence in the atmosphere of substances resulting from acts of man in quantities which are or may become injurious to human, plant, or animal life or to property. All aspects of employer-employee relationships are excluded from this concept.

We all know that air is a natural acceptor of waste materials and no one is concerned until too much waste material is put into the air. The only legitimate objective of air pollution discussion is to determine how much is too much. Certainly the economics of the problem substantiates the need to dissipate some of our waste products by releasing them into the air. Where to draw the line is the question which has brought all of you here.

Air Pollution Control Is Basically an Economic Problem

Control of air pollution costs money—a lot of money—and eventually the public foots the bill for such a program in paying higher prices for the products produced by industry and higher taxes to maintain air-pollution bureaus. How much is the improvement worth and how much should properly be spent? Those are really the basic questions.

The costs of air pollution, including both the costs of the effects of air pollution and the costs of attempting to abate it, have been estimated at $65 per person for every man, woman, and child in the United States for each year. On the effects of air pollution, it has been estimated that at least $4 billion is spent each year by industry and the public as a result of air pollution. Property values are decreased, materials are damaged by corrosion, and household bills are increased as the housewife valiantly tries to keep her home neat and clean.

On the other side of the ledger, industry is spending tremendous sums and these will increase, in an attempt to control air pollution. The chemical industry estimates that it spends $40 million a year to operate its air-pollution control measures. One utility company recently spent $16 million to install smoke-elimination equipment on its electric power generating plants. Almost without exception, American industry is spending huge sums in an attempt to do a voluntary job of reducing air pollution or in an attempt to comply with regulatory measures.

Claims for damages and lawsuits are pending in this country in an aggregate that would easily amount to $50 million. Much valuable executive time is spent in appraising these claims and preparing for their defense.

Within the bounds of present technical knowledge, a great deal can be done to control air pollution—but at tremendous cost. Again, we are back at the initial question. How much control is feasible in view of its cost and how should the cost be borne?

Air Pollution Is Fundamentally Local in Character

As previously mentioned, air pollution means something different in Los Angeles from what it does in Pittsburgh. The problem is different in Seattle from that in Birmingham, different in Oak Ridge, Tenn., from that in New York City. Each localized air-pollution area is unique. The amounts of emission vary greatly from place to place and the natural atmospheric dispersion, which depends on air movements and topography, varies greatly. The waste load capacity in a given area is affected by the height and relative location of the smoke stacks or other points of emission. The type of effluent varies greatly. All these factors make it self-evident that air pollution is a localized problem and that blanket regulations enforced on a broad scale without regard to local problems or local consequences are both economically and scientifically unsound.

Control Efforts Should be Based on Scientific Facts, Not Hysteria

Great strides have been made in the engineering aspects of air-pollution control. Equipment has been devised for eliminating, to some degree at least, a large proportion of pollutants from waste effluents. However, a high degree of elimination is not always possible, at least at a cost which society can afford. Science has not yet found a means to effectively control some type of effluents, and some effluents are perfectly harmless and not worth the money required to control their emission.

At present, knowledge about the effects of air pollution on plant and animal life and on property is limited. The cause and effect relationships in many fields have not been determined. Notwithstanding the obviousness of the point, it needs to be constantly reiterated that air pollution should rest on facts and science and not on hysteria. Each time action is taken on the basis of public hysteria before the facts are determined and the scientific limitations understood, good government suffers and an economic loss is incurred.

Effective Pollution Abatement Requires Cooperation of Industry

To whatever extent a reduction of the amount of pollutants going into the air is sought, the only way this can be accomplished is through action taken by the source of emission which, for the sake of generality, I will refer to broadly as industry. In other words, while city councils may legislate, the abatement itself must be made by industry.

Recognition of this truism would do a lot to obtain better results. If industry is to be induced to do a good job, it must be encouraged to believe that (1) the intended result is really beneficial to the community, (2) that all industry will be treated alike and no one company singled out for special treatment, thus disturbing the competitive balance, and (3) that the abatement program will be handled by competent people who know what they are doing and who are capable of appreciating and coping with the difficult problems frequently faced by industry in achieving the desired result.

We in Pittsburgh know that this is so because the attitude of wholehearted cooperation engendered between government and industry to produce a cleaner air has created an atmosphere in which industry wanted to do a good job and in which it has done a good job, with the help and cooperation of the governmental agencies rather than their hindrance.

The human quality of preferring to work for an appreciative audience rather than a critical audience is true in this field as it is in all others. Unless the whole context of the abatement program convinces industry that a bona fide effort is going to be made to accomplish a worthwhile community objective in a fair, equitable, and reasonable manner, industry won't do a good job. If industry won't do it, it won't be done, for no amount of fines will produce abatement.

Existing Air Pollution Control Legislation

Still the great bulk of control legislation is at the municipal level, with a few overtures being made toward the establishment of air-pollution zones which overlap municipal boundaries. Statewide laws are now in effect in New Jersey, New York, California, Oregon, and

Washington. Agencies of the Federal Government are taking an increased interest in the problem though not in a control capacity.

Each year we have hundreds of new air-pollution-control laws introduced in the legislative halls of our cities, counties, and States. Numerically, the greater bulk of these proposed bills are very bad and will not produce a workable law that will achieve the intended result if an air-pollution-abatement law is found necessary or desirable.

A good law should be prepared, tailored to meet the local situation, or else the time of all concerned is wasted. There are many suggestions on this subject available from several sources, and a good law can be intelligently drafted to meet the specific problem faced by the community. If the law is no more than a hunting license for the enforcement bureau to seek down and harass isolated cases with no knowledge of cause-and-effect relationships, then all that happens is that tempers are aroused and all chance is lost to achieve something worthwhile.

Conclusion

With respect to the assigned subject of industrial investments, taxation, and community relations, it is my hope that I have emphasized that industry now has tremendous investments in air-pollution control and that with each passing year this total will leap upward. Industry has a tremendous responsibility, and cleaner air can only be achieved if industry is induced to embrace the local program and cooperate. This it cannot be expected to do unless it knows that its competitors will be made to comply similarly, and that the law will be fairly administered on a sound scientific basis.

With respect to taxation, because the capital investment of industry is so high, it has been frequently suggested that the Federal tax laws should be amended to give industry a vast tax writeoff of these capital expenditures. No doubt this would influence the corporate executive in deciding how much to spend and when to spend money for air-pollution abatement because his tax dollar is also used. On this subject, the individual citizen has a clear investment in the effectiveness of any air-pollution program conducted in his community.

Community relations are all-important. Industry must sell the community that it is trying to do a good job, but I want to emphasize again the point that is often overlooked: namely, that the community, represented by its enforcement officials, must convince industry that the community objectives are desirable and reasonable and will be reached by a fair and scientifically sound program.

Impact of Air Pollution Control Programs on Our Economics and Society—Byproduct Recovery and Development

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The economics in air-pollution control are basic because both industry and the general public can be penalized for their operations. When restrictive measures are imposed without reservation it seriously affects our economy. For industry, the hope in any economic evaluation of an air-pollution problem is to obtain a solution without excessive cost and under conditions which do not suspend or interfere with operations for any protracted period. The ideal approach is to recover a byproduct that is salable or that can be returned to the process. This has been demonstrated many times and, on occasion, invested control dollars have come back with a profit.

Unfortunately, not all economic aspects of air-pollution control are so favorable. A large number of waste gases contain materials and particulates which have no real value at present, or their value is so slight as to be insignificant in offsetting the cost of the control equipment. The burden of this type of pollution control can be called the price of good community relations, and much equipment is installed for this reason to the credit of industry in general. When the cost of such equipment, however, becomes so disproportionate in relation to the cost of the operation that it exceeds the cost of an ideal solution or cannot be amortized over a reasonable period of time or be otherwise justified, then we must seek less expensive, but still effective, methods for control. This emphasizes the need for less costly air-cleaning devices from both the capitalization and operating aspects. Federal money devoted to such research benefits both industry and the general public.

The serious economic consequences of atmospheric pollution recently have been impressed upon the British citizen by estimates made in the Beaver Committee report. The cost to Great Britain has been estimated at 250 million pounds per year in direct costs and loss of efficiency. When, in addition, the loss due to the imperfect combustion of coal is taken into account, the total sum approaches 300 million pounds per year.

In this country the loss from air pollution is estimated at between $3 and $4 billion annually. About $300 million is said to be spent for control each year. While these figures are not recognized as accurate, nevertheless, they do indicate the magnitude of our economic problem.

Air pollution control in the United States has emerged from considerations of smoke and fly ash to a full program giving attention to the total environment. Waste disposal problems, both industrial and public, are aggravated by population growths, the speed and proportions of which demand vastly better use of our air supply. Atmospheric contaminants include a host of gases, mists, vapors, dusts, odors, radioactive particulate matter, and even pollens of allergenic significance.

Personnel giving active attention to problems of improving our air environment are now of professional scientific standing. They use portions of several academic disciplines in the study of questions like these: What is in the air? How do we measure its quantity and quality? How do pollutants behave when in the air? How may they be lessened? The student of air pollution may now perfect his training through special curricula offered in several universities and colleges in addition to training courses offered through the United States Public Health Service and some State departments of health.

The expert in air-pollution control uses the skills developed in the field of instrumentation to collect atmospheric samples and the discipline of chemistry to learn what is in his sample. He has learned that the chemistry of the air is extremely complex. From meteorology he learns of the movement and behavior of our atmospheric blanket and of the behavior of unwanted substances released for air transportation and circulation. The principles of engineering are needed to design and operate control equipment and, frequently, chemical engineering and electrical engineering know-how must be had to understand its operation. From medicine and toxicology come interpretations on health aspects of airborne substances likely to be harmful. Epidemiological studies are only beginning to evaluate the effect of polluted air on our people. This effect has been clearly demonstrated in the episodes of London, Donora, the Meuse Valley, etc.

The profession of industrial hygiene includes portions from these disciplines and for this reason it is natural that many industrial hygienists are actively participating in the study and control of atmospheric pollution. This turn of events—that is, the putting together or emerging of a new profession—is only a repetition of history in our country and it would seem that once again we are pooling knowledge for the education of those who eventually will solve the problem of air pollution.

The education of technical personnel has only begun, but it must continue, for it has made possible an ever-increasing body of research know-how in air-pollution cause and abatement that already has made possible the solution to a host of complex control problems. In fact, the control of a great many air-pollution problems is known today, but what is lacking is the general application of this present knowledge. It is this area, the knowledge about control problems now solved, that should constitute a second educational effort directed toward the general public as well as toward industrial management. The collecting and dispensing of this information will be a worthwhile accomplishment.

Most air pollution problems may be classified as follows:

1. Open burning dumps.
2. Smoke, gases, and fly ash from the combustion of fuel.
3. Dusts, mists, gases, and fumes, including radioactive dusts.
4. Pollens of allergenic significance.

When air contaminants arising from these four categories are controlled, our pollution problems will be at an end and the air we breathe will certainly lose some of its spice.

Understanding the causes of air pollution through education will bring a realization that we are faced with only one problem, but that there are two contributors—the general public and industry. Both groups must come to realize that they are contributors in all four categories and, quite likely, in almost equal proportions.

Because pollution is everybody's problem, it is necessary that educational activities toward abatement be forceful and dynamic. It must be firmly established that only through cooperative effort will come a solution to this problem. This is hardly the time for choosing sides as in a contest. It is time, however, that the economic benefits and burdens in air-pollution control for both public and industry were well understood and appreciated.

In all fairness it must be said that many educational programs for pollution abatement have been sponsored by industry in efforts directed toward self-education. Forward-thinking industrial management has sponsored industry association programs as a voluntary movement without thought of future air-pollution legislation. These programs, together with those of professional scientific organizations, have prompted the spending of large sums for research that have extended the horizons of our knowledge. We are no longer at work in an academic vacuum. The majority of industrial managements have demonstrated their cooperation for cleaner air and consider that properly constituted and fairly administered control legislation will serve as a spur to those who may be recalcitrant.

The general public has not taken comparable steps in self-education. Educational programs directed at both industry and the general public to evaluate the air-pollution potential in realistic terms have not kept pace with our training of pollution-control scientists. Certainly, these programs have not kept pace with complaints of pollution. Control programs can be motivated, it would seem, by developing an understanding of the economic and social benefits derived from pollution abatement.

The educational program will need to break down the tradition of acceptance of the "status quo" and substitute action for lethargy. For example, many segments of the general public have recognized that their rather archaic bonfire method of household rubbish and waste disposal is a source of smoke and odor when burned on open dumps. In addition, the dump is usually known as a breeding place for rodents and insects. When these municipalities faced the cost of proper incineration of wastes, the prospect was often staggering, and control funds were not always voted. Also, many municipal incinerators operating today are not designed to permit their use in destroying dead animals, offal, or waste such as from a poultry establishment. These disposal problems require additional municipal funds to pay for burial. Yet taxpayers may not understand this when voting for the cheapest incinerator that can be built.

Many municipalities do not realize that there exists a less expensive solution to their problem. It is the sanitary land-fill, which may be established and operated at much less cost than incineration. It will convert marginal lands into parks, playgrounds, industrial sites, and other uses that can gain new ratables and lower tax rates. Capital investment for heavy equipment to operate a sanitary land-fill is approximately one-tenth of that required for incineration. The cost of garbage and refuse disposal by the sanitary land-fill method is approximately one-third of the cost of incineration. In some areas sanitary land-fills are now paying their own way or are showing a profit.

The economic disposal of the public's wastes is but an illustration of the fact that there is more than one way to solve our problems. Public contribution to air pollution extends further in our use of automobiles, the burning of fuel to heat our homes, as well as operating our backyard incinerators. The public can contribute its share to air-pollution control, and this is shown to be possible when undertaken by those that are informed. Our problem is not "What are the facts of economic waste control?"—that much is well known—but "What is the best way to disseminate this information?" Every municipality has the obligation to provide for the proper storage, collection, and disposal of waste produced by the people. Just how soon the public will insist on more economic disposal of its wastes will depend to a large extent on the effectiveness of this educational program.

A program for the education of industry should point to the economy that accrues when air-pollution control is drawn into the blueprints and installed as a part of new plant construction. A tribute to the resourcefulness of industry are the many air-pollution-control installations that return some economic benefit in the form of byproduct recovery. In fact, through industrial funds expended for research has come the development of formerly unwanted byproducts into salable items. Today most dollars spent on air-pollution control and operation of control equipment are written off as the cost of doing business. There is no tax benefit, but the trend is for more and more returns on invested control dollars as new uses are found for these byproducts.

In our company most air-pollution-control installations do not have a profitable return on investment in terms of dollars that may be shown by accounting methods. However, all installations have intangible benefits, some of which are most rewarding. A few of the installations that show savings are mentioned here.

Leftovers from antibiotic production now find their way into animal feed supplements, and a former disposal problem has been turned into a profitmaking item. At one plant four boilers are equipped with multiclone dust collectors. The installation cost was approximately $64,000. It is estimated that they remove about 4,000 tons of fly ash each year. The dust collectors return the collected ash and coal back to the grates of the furnace. The collected fly ash contains about 70 percent carbon and the value of fuel saved on an annual basis is about $32,000.

A steam stripper was installed in 1951 to remove volatile benzothiazole that caused a neighborhood nuisance problem. The cost of the steam stripper was approximately $85,000. The value of the benzothiazole recovered annually is approximately $50,000.

The tail gases from sulfuric acid absorption towers in a contact acid plant are passed through a final packed tower over which sodium sulfite is circulated to absorb residual amounts of sulfur dioxide. The sodium sulfite reacts with the sulfur dioxide to form sodium bisulfite. The sodium bisulfite is later acidified to release the sulfur dioxide, which is then compressed and sold as a byproduct. The bisulfite absorption tower was installed a few years ago at a cost of about $14,000. Approximately 5½ million pounds of sulfur dioxide are recovered annually. The value of the recovered sulfur dioxide is on the order of $160,000. However, the processing costs are such that no profit is made in the operation. But intangible benefits occur in control of both air and stream pollution.

Certain sludge wastes, that formerly were discarded on the dump where they contributed to a pollution problem of both air and water, are now converted into an item that about pays for itself. A Dempster box of sludge costs about $5 to process. It takes 0.7 of a box of sludge to make 1 box of compost which sells for $5.

Last year 12 large industries in Perth Amboy, N.J., spent $12 million on air-pollution abatement. A total accounting of financial returns on this investment is not yet available, but one company saves the cost of buying and handling 1 million gallons of water monthly as a result of only one part of their air-pollution-control program. Another company recovers 8,000 tons of sulfur per year, which formerly was burned with refinery fuel gases.

In other industries, waste wood is used to make outer surface veneers for furniture. Citrus wastes turn into cattle feed, and valuable extracts result from the byproducts of juice extraction. Petroleum gases, once burned, are now raw material for the petrochemical and other industries. The recovery of noble metals from smelter gases has provided an economic return that has offset the cost of recovery.

The baking ovens in an enamel-coated metal strip operation gave off pungent solvent fumes, causing an air-pollution problem. Installing a catalytic oxidation unit to burn these gases resulted in considerable fuel savings, a 400 percent production increase, and the tumbling of insurance rates from $1.25 per thousand to 6 cents, a 95 percent decrease. The $30,000 investment has more than paid for itself and has brought a priceless commodity, neighborhood good will.

Research reports show several methods for the recovery of fluorine compounds occurring in low concentrations in gases escaping from the processing of phosphate rock. Already the sale of these byproducts returns a portion of the costs required for atmospheric pollution abatement. The development of such byproducts of salable quality is worth further investigation.

Overfire jets reduce smoke and increase boiler efficiencies when burning wood. A furniture manufacturer eliminated in-plant as well as out-plant air pollution from sawdust and reduced fuel costs spent to heat 70,000 cubic feet per minute of air that formerly was exhausted from this plant by equipping his furnaces to handle wood wastes. A saving of 33 percent fuel costs resulted.

Chlorine users and producers have the problem of recovering this gas from air-chlorine mixtures. One company estimates their cost to recover liquid chlorine is approximately $19 a ton compared to a market price of over $60 a ton for chloride in tank car quantity.

Many proven processes have demonstrated efficiencies in recovery of byproduct sulfur dioxide and hydrogen sulfide. The literature is quite voluminous on this subject and the U.S. Bureau of Mines recently published the results of their research in the recovery of sulfur dioxide that was sponsored by the U.S. Public Health Service.

The Fulham-Simon-Carves process for the recovery of sulfur from flue gases has been reported from Great Britain. While the process is still new, studies on its pilot plant indicate beneficial economies. Estimates on a full-scale plant, dealing with combustion gases from coals containing about 1.5 percent of sulfur, show that the revenue obtained from the sale of the byproducts should practically compensate for the costs of installation and operation of the plant. If the gases are derived from fuels of a higher sulfur content, the plant could probably run at a small profit. During the limited time the plant has been operating, no undue maintenance work has been encountered and all units and materials of construction appear to be adequate for the duty expected of them.

Detroit Edison, burning about 5.5 million tons of coal a year, has created a market for fly ash which in 1957 resulted in sales of 105,000 tons. With the rapid growth of the company, efforts to expand fly ash commercialization continue to be important. Like the volcanic ash used in construction of 2,000-year-old Roman edifices, fly ash reacts with lime to form a durable, cementlike composition. For more than a quarter century, the Detroit Edison Co. has been investigating the use of fly ash in concrete and other building materials in the hope of transforming an old liability into a new asset.

For example, in 1957, about 340,000 tons of fly ash were produced by the Edison plants. The 105,000 tons were sold at $1 a ton to manufacturers and contractors for use as a raw material in portland cement, as a mineral filler in asphalt paving mixes, and in the manufacture of concrete products. Dumping the 105,000 tons would have cost the company about $78,000.

It is interesting to note that about 32,000 tons of Detroit Edison fly ash were used in the construction of the 5-mile-long Mackinac Bridge which now links Michigan's Upper and Lower Peninsulas. Outlets for fly ash include use in ready-mix concrete, building blocks, slag and clay bricks, road base choking material for highways, lightweight aggregate manufacturing by sintering, metal polish agents, mild abrasives, sand substitute in sandblasting, filtering media, and filler material for roofing and putty and for land-fill reclamation.

Turn back in history to 1951 and see the ingenuity of industrial research in developing economic pollution-abatement processes.

Hydrogen sulfide, inherent in refinery gases, produces sulfur dioxide when these gases are burned as fuel. Research by the petroleum industry determined that these waste gases could be stripped of hydrogen sulfide, which then could be converted to valuable sulfur and sulfuric acid. They sold hydrogen sulfide to chemical companies and received operating benefits from reduced corrosion when burning the cleaned refinery gases.

To control odor, three fish canneries installed low-pressure gas dehydration equipment. While the cost of each unit varied between $12,000 and $25,000, and power had to be increased as much as 10 percent, the gas consumption was cut as much as 10 percent and maintenance costs were actually reduced. All three companies report a general improvement in the quality of their fishmeal. As much as 15 percent more salable material was recovered with the new process. One firm realized an increased value of $4.80 a ton in its fishmeal because the protein, vitamin B_{12}, and lysine content was higher. Another concern recovered its $13,000 expenditure in 1 year.

Use of prebaked oil as a core binder cut core banking time more than 25 percent on the average and greatly reduced visible smoke and odor from core ovens. Management, personnel, and nearby residents were much gratified with the improvements initiated through the enterprise of this company.

Over 50 percent of the substance recovered in secondary lead smelting collection systems is lead oxide, which may be sold or recharged to furnaces. This material amounts to as much as 1,000 pounds a day in large plants.

Activated bentonite clay, used in the catalytic cracking of crude oil, is an important commodity which one clay company learned it had been losing to the air in quantity. An efficient collecting system recovered enough clay fines to market a high-grade contact catalyst for the decolorization of fatty acids and oils.

A paint firm invested over $7,000 in fume-collection equipment on its varnish cookers and recovered two or three 42-gallon drums of fatty acids a week.

At a cost of $8,000 a mineral processing company installed equipment to collect fines lost in its grinding operations and hoped to write off the expenditure in 2 years at the earliest, but the recovered dust proved to be of such exceptional quality that it brought $5 a ton more than the original product. This control process alone grossed over $25,000 a year.

Over 1,400 pounds of feed a day were being lost by a grain mill before collection equipment was procured. The recovered fines were mixed with the main feed and production costs cut appreciably as a result.

An alfalfa-mill owner was suprised to learn that cattle he grazed behind his elevators preferred alfalfa fines to their usual diet of hay and molasses when the two were placed side by side. Tests revealed that the protein content of its fines was higher than in the regular product. Dust collection has stopped air pollution and is earning its way.

It is not accurate to say that all air-pollution-abatement systems result from conformity with air-pollution-control regulations. Rather, many advances have grown out of the realization on the part of industry that pollution of the air, whether unpleasant to the smell, irritating to the eyes, damaging to the crops, or haze producing, is not proper and sooner or later must be met. Fortunately, many industries are now and for many years have been engaged in independent research on the methods of reducing pollutants. In spite of what has been accomplished in the past, byproduct recovery and development is only in its infancy and large economic rewards from air-pollution abatement are yet to be realized.

The ingenuity of American industrial management was never greater than today. From industry's dollars spent on air-pollution-abatement research will come the solution of these problems for both industry and the general public.

In summary, our goals for the future might be these:

1. A well-planned program to expand and extend the education of more personnel in the profession of air-pollution abatement.

2. A well-planned program of education for industry and public alike about the economic benefits that are possible today in air-pollution abatement.

3. To establish in the national headquarters a center for the collection and dissemination of existing know-how in air-pollution abatement, so that this information may become common knowledge.

4. To channel research funds into studies of byproduct recovery and development processes for collected air contaminants.

5. To channel research funds into studies seeking less expensive pollution-abatement techniques.

6. To establish a liaison between Government and industry that will break down restraints or fears of punitive measures and that will replace suspicion with cooperation.

7. To create a team approach between the public and industry for cooperative responsibility and effort in pollution-abatement programs. The time and money spent by industry to defend litigation is needed for research.

These seven goals, while long range in scope, can be inaugurated today so that dividends of cleaner air, mutual trust and understanding through education, and a desirable economy eventually will accrue in our air-pollution-abatement efforts.

The challenge to Government is to help industry and the general public to help themselves.

Impact of Air Pollution Control Programs on Our Economics and Society (3)—Community and Social Implications

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The poverty of information on the subject of air pollution is as nothing compared to the poverty of research on the social or sociological aspect of the subject, the consequences of it. To begin with, I may say that there is no evidence that I am aware of that communities, as communities, have been hurt in any way by air pollution, but individuals may be badly hurt. They are certainly greatly inconvenienced. That is apparent to everyone. But if I were to give you a scale of the worst community in the United States, rated by the usual criteria of public service, cultural, intellectual, educational opportunity, and so on, a scale of the worst community in the United States and the best community in the United States, you would probably find that some of the most air-polluted communities in the United States are up at the very top as being among the best communities in the United States. And the worst single community that I as a sociologist have ever visited or had anything to do with was a community that had nothing whatsoever to do with industry and there was no air pollution within 500 miles of it, that is, air pollution as anything to be concerned with. So, if we are going to rise above the level of merely talking platitudes about air pollution being inconvenient and people won't come to the community and this and that, we have really got to dig into the subject to find out what, if anything, air pollution does to a community. So far, it is beyond my evidence, beyond anything I have been able to discover, that air pollution as such has any particular consequences to the community as a community, in contrast to individual comfort and discomfort.

One of the disadvantages that air pollution has as a human enemy is that it lacks the clear, dramatic impact of something like cancer or polio. It is much more difficult to mobilize human action on the subject of air pollution than it is on, say, polio or cancer. We have nothing yet, nor do we seem likely to have anything, quite comparable to the March of Dimes or the Cancer Fund.

Similarly with malaria. Malaria used to be a major problem in the United States—and still is in other parts of the world—but ultimate control of malaria depended only to a small extent upon the behavior of the general public and communication with the public. To a much greater extent such control was the result of the concrete discovery of the role of the anopheles mosquito and of the imposition of preventive techniques which did not seriously disturb the individual liberties of the population. Very different indeed is the problem of air pollution. Efforts on the part of the air-pollution control authorities to implement or effectuate their policies frequently run smack against the mores and the general sense of values and the idea of having freedom to do as one likes or as one wishes or elects.

As a sociologist, I am most struck by air pollution control as a sheer problem in communication. Now communication, as I think all of you know, involves a good deal more than simple use of words. It is also a matter of sentiments, habits, loyalties, and what I can only call predispositions to belief and behavior. We all know that communication is oftentimes difficult enough within the small compass of the family, but it becomes extraordinarily difficult when one expands the range of the group to a city or to a local region. To try to put forth a message or policy to a large number of differentiated people is extremely difficult because of the problems which are involved in the way of blocks—blocks which are created by economic interests, religious interests, educational differences, and the like.

I can compare it, I think, to the flow of rainfall over a landscape. It does not run evenly and smoothly. Always the flow is diversified in seemingly erratic manner by the presence of innumerable contours of the landscape.

We, as sociologists, know when we are dealing with the problem of communication with the population, that we have the same kind of erratic flow and reception of communication. The moment an announcement or policy leaves the sending officer or agency, the pattern of understanding, far from being homogeneous and simple, becomes differentiated and variegated in terms of all the predispositions which exist in a population: predispositions of an economic, educational, political, and even religious sort.

But the problem of air-pollution control, as I would see it, goes beyond the ordinary difficulties of mass communication. The first point to be understood here is that a concern for pollution of any kind is by no means native to human beings. What we are willing to tolerate in terms of pollution and filth varies not merely from individual to individual, but from group to group and culture to culture.

Not very long ago I was talking to an anthropologist friend of mine, a very distinguished young man who was back after a year doing field work in East Africa. While he was in East Africa, he spent a number of weeks with one particular tribe of Bantus. This tribe was not very sanitary by our best standards; food scraps and human and animal waste all too often covered the ground. My friend, although he is a hardened anthropologist by this time, after 2 or 3 weeks was beginning to find it a little annoying. One day he was talking to one of the sons of the tribal chief. This son in earlier years had had quite a bit of schooling in a nearby town, in a mission school. My anthropologist friend was about to express his disgust at the filth and waste which lay on the ground, but he didn't. The angel of mercy got to him just in time, because the young son of the chief began to speak, and he said, "You know, when I was in school in the mission school, I used to read with great interest about your cities in the United States and in Europe and," he said, "I found myself on occasion wishing that I could visit your cities. But," he added, "I decided long since that I really don't want to visit you in the United States or in Western Europe because it is apparent from what I read that you foul your air beyond all point of decency."

So my anthropologist friend decided not to press the matter of pollution of the ground.

We have to understand that even in our own society tolerance of pollution varies a great deal. Some do desire to do something about air pollution. As human beings, we all tend to arrange our desires and dislikes more or less unconsciously on a kind of scale. When I say I like something or I don't like something, what I really am saying is that in connection with certain other things I like this or in relationship to other matters that confront me as an individual, I dislike this. Every statement of like and dislike is really a relative statement and on a scale that has complete, absolute infatuation with something at one end and total abhorrence at the other end.

Now the greater or less intensity of one's dislike is governed by the intensity of various other dislikes and abhorrences.

Now let's remember that air pollution is only one type of pollution. How we react to it depends not simply upon how bad it is intrinsically, but upon the extent to which other pollution-nuisances have been obliterated or abated. For example, the slum dweller who is accustomed to the general pollution of his tenement, his streets, playgrounds, and even the food and water that he eats and drinks in his tenement flat, is less likely to react with dislike to air pollution than someone for whom cleanliness of environment has in large measure been achieved.

You can go through square miles of Chicago and St. Louis and Los Angeles and New York and if one were to ask what is unpleasant in that area, I am sure it would take a long time before one would come to polluted air. There would be so many other things to comment on in terms of filth and pollution that have not yet been cleaned up.

The point I am trying to make is that a willingness to do something about air pollution is marginal. It is marginal to the extent that one's desires, one's feelings, have already become satisfied by other reforms and improvements in the atmosphere, in the general area that he lives in.

Speaking as a sociologist and, as I said, in a field in which no sociological work whatsoever has been done, may I say parenthetically that I wrote to 11 different people who are active in the country with air-pollution control work, asking for guidance 2 or 3 months ago when I learned that I would have the privilege of coming to this meeting, and from not one of them was there the slightest ray of hope, the slightest bit of evidence that anything of a sociological sort had been done either in the study of consequences of air pollution to a community or in terms of consequences of air-pollution control systems.

I will come to that a little later.

As a sociologist then, let me say that the cause of air-pollution control would be greatly helped if there were clear and easily demonstrable evidence that air pollution has a relationship to the preservation of human life. I thought a few weeks ago that I had some hope, because a scientist friend of mine called up and said, "I have just been reading a rather technical article in the U.S. Naval Institute Proceedings on the subject of carbon dioxide and there is a statement in here which indicates that air pollution is a cause of suicide and mental illness."

"Well," I thought, "this is marvelous because it has been 52 years since anybody has come forth with a fresh theory on the cause of suicide, and it is really going to brighten my whole life as a sociologist if we could just get something new on the subject of what causes suicide."

So I ran—not walked, but ran—to get this copy of the Naval Institute Proceedings, to read this article on carbon dioxide, most of which I could not understand, but I did come to a paragraph in the middle of it which said that air pollution causes higher rates of suicide and mental disturbance or mental illness. And what was the evidence? It was that cities that are high in air pollution are also high in the rates of suicide and mental illness!

Well, need I say anything more on that basis? On this basis, we could use air pollution as the cause of industrial strikes and traffic congestion, the cause of high wages, of concerts, of good educational systems, etcetera, etcetera.

I will admit, however, that there have been days in Los Angeles when I have been there, when either suicide or schizophrenia seemed attractive as a way out. But alas, there are no evidences.

Let me say in what follows in the next few minutes that I am offering these, not really as suggestions from a bush-league Machiavelli, but as comments on how air-pollution control campaigns or air-pollution control movements might be most effectively prosecuted, based upon what we in sociology know about the behavior of human beings.

First, let me distinguish for you informal and formal government. To proceed on the assumption that the only persons to interest are public officials is folly. Every human community is composed not merely of a formal government, represented by elected and appointed officeholders, but also an informal government, which is composed of men and women who have nothing to do with the official operations of a community but who, by acquired prestige and influence in their professional, business, or associated lives, must be regarded as significant elements in the total government. And whether one is trying to popularize a new soap or automobile or to popularize a campaign such as air-pollution abatement, these are the persons always to reach first. Oftentimes they comprise—and I am thinking here especially of the wives of influential industrialists—what Winston Churchill referred to as the "soft underbelly" of the industrial front. An industrial executive may be utterly aloof to the reforms and changes necessary to control of pollution, but he does not live his life solely as an executive; he is also a husband, a club member, an alumnus, and, in our country, undoubtedly active in PTA, Rotary, or similar organizations.

Now our studies—and we have made lots of studies of the voting behavior in the United States—have made very plain indeed that individual decisions as to a proposition, bond issue, candidate, or what have you are oftentimes arrived at not so much in terms of formal publicity or in terms of formal campaign addresses as they are through the interpersonal experience of being with others who are shaping their decisions at the same time.

For example, if you belonged to a club that you prized very much, it could be—we have discovered repeatedly—of more importance in making your decision on so secret a matter as a vote than the sum total of what the candidates have to say on that particular election. The Elmira, New York, studies have left very little doubt on this aspect.

I come to the next point, the social-economic status. As sociologists we have discovered that in addition to other determinants of human action and belief, one's social-economic status is important. Now contemporary America is not a class-organized society, but it is a status-dominated society. There are no classes. These are mere figures of speech now to refer to lower, middle, and upper class. There are no real classes, but we are all of us very strongly governed by individual status considerations and, believe me, we talk sometimes about the silly Hindu who will pass up food because of a religious taboo that forbids him to eat beef, but that is nothing compared to what many of us Americans will do in passing up our own economic interest in order to respond in terms of what we conceive to be proper to our status, our individual status.

Now the evidence indicates very clearly that people of middle and upper social-economic status are far more prone than others to join clubs and organizations. And equally, they are more prone to participate in movements which have some kind of uplift or improvement as their objective.

It is sometimes said that America is a nation of "joiners," but the evidence is very clear on this point: only middle and upper social-economic status Americans are joiners. Add to the general fact of such proclivities the further fact, suggested in the early paragraphs of this paper, that only among people for whom total cleanup of environment has become a nearly realized ideal is there likely to be much concern with that single type of pollution that is air pollution. Let me single out women for their special potential contribution. They are a very powerful pressure group or potential pressure group in the United States. In my opinion at the present time, if properly organized they would be the single most powerful pressure group in this country, more powerful than the sum of national associations of manufacturers, organized labor, or anything else. If you just organized women as women, they would be a most powerful pressure group. It used to be said, "Don't worry. you never will, because women, first of all, are daughters of men, daughters of fathers, and, second, they are wives of husbands and they will always repsond as the male does". There was for a while some evidence of this, but this is not so true any more and it is becoming apparent again in our voting studies that women are becoming increasingly a self-conscious minority-majority group, or whatever you want to call it, in the States. I spoke about the "soft underbelly" of the industrial front, and let me tell you that the wives of the industrial managers and executives have a great deal to do with being a part of this "soft underbelly" of industry. And as a sociologist—here I am guessing because there is no evidence—I would surmise that air-pollution campaigns will draw their greatest strength from women between the ages, approximately, of 19 to 49 or 50. Younger women, that is, women younger than 20, are not likely to be much concerned with air pollution as against the monumental excitement of dates and trying to get "A's" or "B's" in college. Women beyond 50, and I am quoting a good friend of mine who is 53 years of age, and she told me that women beyond 50 by that time have either become totally disorganized by their early family responsibilities or else they have settled into a calm and mellow tranquility which not even air pollution is likely to disturb. So the evidence is fairly clear that most of the Carrie Nations—I don't know how many of you remember good old Carrie Nation—of the world are at the peak of their activity and effectiveness in their thirties. If they go on into their 50's still carrying axes and breaking up saloons or bars as good old Carrie did, it is because they acquired the firm habit in their 30's and 40's.

There is also the matter of neighborhood pride. That is something which also could be capitalized upon, mobilized, and exploited in this direction. The neighborhood is a unit that sociologists a generation ago used to say was on its way out; that we are going to be a great nation of cities and the neighborhood is about gone. There were a lot of architectural plans even as late as the 20's that seemed to reflect this, but this has turned out to be utter nonsense. The neighborhood is becoming an extremely strong unit in American society. Such writers as David Riesman and William F. Whyte and others point out, the neighborhood today in suburban form has become a strong unit, especially among the upper-middle and upper social-economic status of American people.

Now whether it is through the morning "Kaffee Klatch" of neighborhood wives or the annual uniting in Christmas decorations that have to extend from one end of the block to the other, the neighborhood is showing an astonishing resurgence of vitality, and with it there appears a pride that radiates outward through the whole community. The neighborhood, then, is a very important part of the informal government to work on as far as any kind of crusade or campaign is concerned and a lot of what has been done thus far in terms of air-pollution controls, as far as I can make out, has come from neighborhood meetings on the subject, as well as other kinds of associations.

Similarly, the feeling of a stake in the community is important. Some of our forefathers in this country believed strongly in limiting political voting to those individuals who had a definite stake in their communities. Our system of democracy gives the vote to everyone alike, and this is fine. But there is, nevertheless, a certain wisdom inherent in our forefathers' prejudices along this line. Those who, by reason of family roots, religious, educational, and recreational associations with a community, have a deep sense of belonging to it will do all that is within their power to protect it, even from activities in which they themselves may be participants.

You see, we seldom live as a completely integrated personality at any given moment. Each of us occupies a succession of social roles. I am a father, but I am also a banker and also a Rotarian. Sometimes my social roles conflict. When they conflict too long, too strenuously, of course, schizophrenia is the result. Most of us stay short of schizophrenia and we are just as our speaker said, confused, but our stake in the community is an extremely important aspect of any approach to the subject of air-pollution control.

I may be wrong on this, but my guess would be that the reason that such suburbs as San Marino and Pasadena have been more active—one of the reasons, not the only one—why such suburbs have been far more active in the campaign to abate air pollution than certain other communities is because these communities are old, they are stable, there are many, many people who have a strong stake in those communities, whereas there are other communities around greater Los Angeles that have many people who are here today and gone tomorrow, who could hardly care less what happens.

Finally we have feedback. This is a word that has assumed a great deal of popularity in recent years amid all the discussions of communication processes. In its simplest reference it refers to a process within automation when a control device has fed back to it, automatically, information as to output that is necessary for its own correction. Feedback is what we lack in very large degree in large-scale organizations and in those agencies which are concerned with informing or controlling the public. We have no real system of feedback. We have no really reliable way of knowing what the effect or the impact of a certain control, a certain ordinance, a certain law is—what the real impact of this is on the people it is designed to cover and whether or not it is really achieving the objective for which it is designed.

You would be amazed at how little we know about these things, but let me say that it is of utmost importance for every air-pollution control district to have persons on its staff so far as possible, or who are at least available for consultation, to study constantly the efficacy of its control, because as an old student of bureaucracy, as an old student of formal government, I know very well the ease with which perfectly well-intentioned controls after a while exist only on a kind of a ritualistic basis. It is comparable to the featherbedding, the horror that one experiences when he looks through building codes in certain parts of the United States and realizes that with all of the improvements, all of the discoveries that have taken place in modern building, what one still has to put into a house or a building in certain parts of this country because the building codes say a four-by-six must go in, when it has long since been proved a one-by-six would do just as well in terms of strain and stress.

There are a lot of agencies in this country—I am not singling out air-pollution control agencies—that have utterly inadequate feedback. I would say that in a matter as delicate and potentially explosive as air-pollution control, the faster we get some useful feedback system, the better. So far, as most of you know, the rest of the country has been feeding and feeding and feeding on the experience of Los Angeles. Well, I take nothing away from the greatness of the achievement of the City of Los Angeles in, so to speak, pioneering. They have done a remarkable job in their air-pollution control districts, but there is a great danger, as I have already discovered, in assuming that, because Los Angeles has adopted a certain ordinance or a certain provision, therefore this must be necessary and we needn't try anything different.

Last summer, when I was serving on a citizens' committee on the subject of air-pollution control ordinances, we came to the all-important matter, one of the most hotly debated subjects in many of the counties of California, the question of having a single permit system or a dual permit system; that is, a permit for execution, construction, and use or just a permit for use alone. There was no evidence that I could find anywhere, nothing but the fact that Los Angeles has had the double permit system; this is all we could get. As far as studies and evidence were concerned, there was nothing. Merely to say that two controls are better than one is nonsense, because building codes and various other kinds of codes in the United States are shot through with ineffectiveness on the principle that two are better than one. Believe me, one oftentimes is better than two.

Now I am not saying that a single permit system is better than a double permit system. What I am saying is that I don't know and I am also saying that I have not been able to find out, because there have been no studies made of the matter.

In conclusion, just let me recommend to all of you an extremely interesting book that Harvard Economist J. K. Galbraith has recently written, called *The Affluent Society*. There is an interesting reference to air pollution and air pollution-control in that book. Mr. Galbraith points out that we have reached the point in our consumer oriented economy where we are living in terms of private wealth and—what shall I say?—public squalor. That I buy with the money I earn a beautiful automobile and what happens? I have to go out on freeways that are congested, so dirty, so dangerous that one despairs of preserving his life in getting to the city and back.

Similarly with air pollution. We have magnificent refineries, we have magnificent industries, we have millions of wonderful automobiles. As Galbraith himself points out, the price of our private affluence is a kind of public squalor and public starvation in many ways and, as he emphasizes, it is only by restoring the social balance, a balance between private affluence and public affluence that we are going to be able to maintain reasonably high standards of living in this country.

PANEL DISCUSSION

Mr. Clayton. I would like to add a few thoughts to Mr. Seamans' comments on community relations. Many large industries today have good community relations programs in regard to air pollution. One such company out west that has sulfur dioxide emitted to the atmosphere, with farms located nearby, has a competent person to evaluate the effects of any air pollution on farm plant growth. This man has authority to make settlements on the spot. This program came about after many years of lawsuits with these farmers and the company found it was much cheaper for their man to evaluate the damage, discuss it with the farmer involved and, if acceptable to the farmer, write him out a check right then and there. That type of community relations is good. The farmers like it. They feel that the company is sympathetic to their problems, and now there is no longer any talk, as there was at one time, of passing laws that would in effect shut down this industry.

Another company I know about has a similar program; when this company receives a complaint about air pollution, their man immediately goes out and investigates. Oftentimes he is able to show that the pollution does not come from the company at all. In one incident of that kind, a woman called, very irate, and raised all sorts of Ned. The company sent their representative over. He listened to her and when he started checking up on where the polluted air came from he found that the woman's husband was burning some rubbish in the back yard, and the wind was blowing it right into the house. Incidentally, she has never called the company again.

The attitude that many industries had at one time was, essentially, to do nothing, ignore the complaints, even hang up on the phone when a complaint comes in. That is fast disappearing. Industries realize that they have the responsibility of being good citizens in a community and they are working at it quite hard.

Mr. LEDERMANN. Mr. Bradley said that air pollution in the United States is lessening. If that is true, it runs counter to my impressions. As an example, I saw recently in one of the magazines that the air pollution problem in Denver, Colo., is getting worse, according to Jack Miller, Air Pollution Control Inspector and the only man in that city fighting air pollution full time. Mr. Miller stated recently that air pollution, as sampled every week by the U.S. Public Health Service, shows a regular increase. He said that every indication is that the problem is increasing as population and industry increase. But I am interested in knowing in which direction the trend actually does run.

My second point: We should keep in mind that every dollar spent on air pollution, to institute new methods of control, must compete with a multitude of other demands for funds, both public and private. In that context I think that conferences of this sort have a certain value in bringing together people such as myself whose primary concern may not be air pollution, but who certainly are interested in it.

To those people who are deeply involved in air-pollution work, the situation is obvious and the urgencies of it are there every day. To others, air pollution is only one of many pressing problems. This is particularly true of municipalities, and it may well be that the amount of education and research that has heretofore been devoted to air pollution has not been as much as it deserves in relation to some of the other problems that communities face.

Mr. BRADLEY. Referring to Mr. Ledermann's first point, there are a lot of things written in magazines and newspapers that many people pay little attention to because there are no facts we can find connected with the stories. We will have to agree that Los Angeles has made a terrific improvement in its pollution control. We will have to agree that Pittsburgh's problem has been lessened to a remarkable degree. There are so many facts that are not refutable, from one city to another, which show that air pollution has been lessened, in some cases remarkably.

In the city of Denver, just starting to find out if they have a problem, the young man there who has the responsibility for air-pollution control on his shoulders is telling about what he is finding. He is not adding new air-pollution problems: he is just reporting on what he finds. As he gets the work underway, he is going to lessen those problems, too.

The record of air-pollution abatement includes that which has been going on for 50 years; even the early work done by the smoke-abatement officers in this country is a remarkable contribution to the lessening of air pollution. That is very true in New Jersey, for example. The few facts that we have show that open burning is almost a thing of the past. A number of new municipal dumps have been completely abandoned. There are innumerable sanitary land fills. Industry is having its waste buried instead of burned. There are hundreds of examples where air pollution has been brought under control. If you look at the facts, you will find that air pollution is definitely being lessened.

Mr. Ledermann. I am aware of the great advances being made in conquering air pollution, but I was wondering whether that progress is keeping pace with the increase in sources that must be taking place each year. I am talking about all sources—through the growth of population, the added automobiles on the streets, new building construction, new industrial plants, and so forth. Is there any measurable evidence that we are reducing the total amount of air pollution each year, disregarding whether or not we are attacking it more effectively, or are the total new contributions added each year outweighing the gains that are made?

Mr. Bradley. There are fewer and fewer new contributions to air pollution added each year than in the past. Ten years ago you would find a number of instances where industrial management was not thinking too much about air pollution or stream pollution when they built a new plant, but today it is unusual to find any industrial management which has not taken into consideration the problems of air pollution and stream pollution when they design, and hunt for a spot to locate, a new facility. While we are getting more statistics and other data from the excellent work of the U.S. Public Health Service, you would get the impression perhaps that this adds to the total amount of air pollution, but it just adds to the total information on what is now existing.

Dr. Ellis Darley (from the floor). As for the type of contaminants Mr. Bradley is talking about, dust and particulate matter, I think it is certainly true that the situation is improving, but in another field in which we are particularly interested—namely, the photochemical reaction that goes on in the air whereby the source materials are completely changed into new materials—the reverse is true. So far as plant damage is concerned, this type of thing is increasing.

I have personally visited the Denver area and I found the type of damage we call oxide damage. It was originally supposed to occur only in the Los Angeles area. It is now found in San Diego and San Francisco; it has been found in Philadelphia, Detroit, and New York. This type of air pollution is definitely on the increase. It is probably associated with ozone and/or other oxidizing agents reacting on a series of organic materials, of which the principal ones are probably hydrocarbons, but I think, in saying that air pollution is becoming less, we have to distinguish the types of air pollution about which we are talking.

As far as plant-damaging materials are concerned, this oxide type of damage is a relatively new type of damage. Dr. Haagen-Smit and others with whom I worked first described this 8 years ago. While other types of pollutants that have been known for years, such as sulfur dioxide dust, we could identify in the beginning and controls have been worked out, this newer type has not been controlled.

Dr. Barthel. Do you mean that you are detecting the damage now, or is it a new damage?

Dr. Darley. The damage that once was typical of the Los Angeles area is now being found in other parts of the United States and in the world and it seems to be associated with growing communities and with the spilling into the air of organic materials in gas form and undergoing reactions that are catalyzed by sunlight.

Dr. Barthel. In other words, this has been going on for some time, but because of expansion of industry and what not, is becoming more prevalent?

Dr. Darley. I can't speak with authority here. I would assume that these types of reactions went on for a long time and are now getting to a level where the concentration is such that plant damage indistinguishable from that which we find in the Los Angeles area is now occurring in other areas in the United States.

Mr. Clayton. Is the damage in these other communities, other than Los Angeles, extensive?

Dr. Darley. In the areas I have visited, it is not extensive, but it is there.

In regard to another point you made, Mr. Clayton, that farmers like the arrangement with industry where industry pollutes the air, damages plants, and then pays off, I am not aware of any farmers who like the situation of continual pollution, continual payoff. If they are being damaged and they have a choice between losing a plant and getting paid for it, naturally, they are going to prefer getting paid for it. But I don't think farmers would accept the situation over a period of years of growing plants primarily for the purpose of being paid off. I think they would eventually prefer to see this industry clean up so that they can grow this plant as it should be.

Mr. Merrill. In regard to assembling air-pollution data, I don't think we are ready yet for overall statistics on the cost of air pollution. I don't think there is any way you can pin it down. I like the idea of a curve that compares the damages with the cost of cleaning up, but it is apparent to me—and I handle figures like that all the time—that your curve will be either meaningless or you can't find the needed figures.

Another thing I think we should consider in our recommendations is that in any community the homeowner, the industrialist, and everybody should do his part. Nobody likes to be played for a sucker and the homeowner is not going to quit burning rubbish if the factory keeps spouting smoke, and the other way around.

Finally, I would like to compliment a representative from American Cyanamid for a refreshingly positive approach from industry. Industry has an opportunity here—big industry, that can afford the research—to lead the way for smaller industry that can't afford research and perhaps provide some of the devices that are needed to clean up. Our large and rich industry has a duty to perform, and it looks like Cyanamid is on the way.

Mr. Mason. On the question of whether we are gaining or losing, when you visit cities like Pittsburgh and Cleveland in recent years you can't help noticing the improvement there. It is obvious to anyone. You don't have to be a scientist or expert to see the gains.

Undoubtedly there are other areas where the atmospheric conditions or the pollutants are such that the problem is very acute and the locality is having a very difficult time. From a layman's standpoint, I don't know whether we are gaining or losing overall, but certainly we have made some important gains in many localities. This is important to us in FHA. I mentioned the mortgage factor. This is only one factor in connection with the mortgage risk, but it is an important one.

I also would like to pay tribute to industry for its part in all this. Again referring to some of the big industrial cities, we find that industry has played a major role in helping meet the problem and also, purely from a good business standpoint, we have seen industry locating outside of town away from the heart of the city, the industrial park idea. There, industry's main objective is to create a new neighborhood that will be attractive to homeowners and also near their place of work.

QUESTIONS FROM THE FLOOR

Mr. Heller. Mr. Bradley, would you please clarify these two points:

(1) Did air pollution as a problem motivate all of the recovery installations which return an economic benefit?

(2) What is the approximate ratio of dollars invested in abatement equipment which shows a loss to those returning a dollar benefit?

Mr. Bradley. You have asked the impossible here. To your first question—Did air pollution motivate all of the recovery installations showing an economic benefit?—the answer is "No." In my paper a great deal of space was devoted to byproduct recovery examples, and there are hundreds of them, but there are thousands of examples where air-pollution abatement has been put in without any return on investments, without the motivation of a return or the development of a byproduct.

On your second question, about the dollar ratio, I just don't have the figures, but one can assume, with a good deal of justification, that the dollars spent for air-pollution abatement motivated by a sense of doing the right thing far outweigh the dollars that have so far been spent for economic returns.

Mr. O'Harrow. Dr. Nisbet, do you believe that the question "to abate or not to abate air pollution" will be answered by the citizens on a clear economic analysis of costs and benefits, rather than be mostly influenced by emotional reaction?

Dr. Nisbet. In my own opinion, the answer will come from the standard of living, the rising standard of decency. It is not easily measureable, but there is a demonstrable rise in the standard of living, and that standard is not something that is external to the individual. It becomes a part of motivation, and when something like clean air comes to be thought of as an integral part of decency and a good standard of living, that in itself will give air-pollution control a powerful push. But if we start assessing many of these things in terms of sheer economics, it is all very well to say that virtue pays, but there is an awful lot of virtue in our society that does not pay. There are high standards of living that are very costly in strictly economic terms, so I think we are probably in trouble if we try to sell air-pollution abatement in terms of economics alone.

Dr. D. B. Andrews. What is the type of response to be expected from the lower income group toward pollution control?

Dr. Nisbet. They won't oppose it and, in terms of concerted action, they won't do very much one way or the other. Most of what is done in this country in terms of voluntary, cooperative action is done by the middle economic group. They are extremely active people. The lower income group may have too much else to think about. Many of them are living in squalor that is hardly calculated to make them very sensitive to the quality of the air. The labor unions may become important allies in time for air-pollution control, but I don't think they are doing much at the present time.

Mr. Merrill. The members of this lower income class are, however, the only ones who hang their wash out in the polluted air to dry.

Dr. Barthel. Florida has a fluoride air-pollution problem arising from a basic industry and someone has asked a question about that. How may the State of Florida receive Federal aid in arriving at limit tolerances and other data necessary before their air-pollution committee can set equitable rules and regulations?

Dr. Brandt. This question points up a basic problem as to what is needed by way of revision in Public Law 159. It also points up a question we have been asking here: What more do we need to know and how can we find out?

The basic law we are working under gave us two responsibilities—for research and for technical assistance. It left the matter of control purely with the local groups, and this is where it should be, because air-pollution problems are local problems.

Research is necessary as a foundation upon which we can build solutions to the problem. No amount of research is going to solve any air-pollution problem, but research is absolutely necessary if we are going to arrive at sound solutions.

As for technical assistance at the Federal level, we do have now, through the technical assistance program, I believe, the mechanism for getting some of these data out and we are doing so.

In the matter of limits, on the specific problem of fluoride, we do have some standards. There are, for example, tolerance levels for cattle. Perhaps Dr. Greenwood would give the latest figures.

Dr. Greenwood. The committee on fluorides of the National Research Council says that under 30 parts per million of soluble fluorides can be tolerated without economic damage to the animals. From 30 to 50 is the borderline area. So the limit becomes about 50 for soluble fluorides, and this applies to consumption during the entire life of the animals, if they are exposed to it indefinitely. For insoluble fluorides, the levels can go higher.

Dr. Brandt. Perhaps what is needed in this case is a recommendation to augment the existing law to take care of more of these cases or permit us to give more adequate support to the type of initiating surveys that may be needed here.

W. D. Miller. There has been a great deal said about fluorides and what it does to plants and what it does to animals. We feel that in this Florida situation we have a very good laboratory where some of these questions that have been posed during this conference could be worked out. We don't feel that Florida should bear all of the cost, any more than we feel that Uncle Sam should bear all of it. We think that it is a nationwide problem.

I agree there is something you can do on cattle. I agree that apparently the plants and trees are having more trouble than they did before. Perhaps we are just recognizing it, but at any rate we don't know enough about it.

None of us wants to be a "smoke farmer." We think almost as much of our orange trees, of our gladioli, of our tomatoes, as you women do of your children, and you are not likely to push them in front of an automobile and then collect damages. We think perhaps if we can have some adequate help in this matter that maybe it can throw some light on these national problems. We don't think it is up to Florida to do the whole thing, but we are not asking the Federal Government to do the whole thing, either.

Dr. **Barthel.** I have a written comment from Dr. John Middleton, our cochairman, who couldn't be with us today, which I think is pertinent to our discussion.

He writes:

> In reading the program, I find no reference to the effects of air pollution upon the high cost of maintenance of electric utility lines in the metropolitan areas. The California Electric Power Co. has been concerned with the short-circuiting of lines, power failures, and flaming of equipment through malfunction of insulators in the eastern section of the Los Angeles Basin. They have assigned special work crews to clean this equipment. This condition does not exist on our powerlines operated by this company outside of the eastern portion of the Basin. I am sure that this problem is not unique to California and may warrant raising a question or two from the floor.

This interesting comment should also be thrown in the pot for consideration this evening when we prepare our recommendations.

DISCUSSION GROUP "E"
CONTROL METHODS AND PROCEDURES

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Dr. Edgar F. Wolf, Superintendent, Electric Test Department, Baltimore Gas & Electric Co., Baltimore, Md.

Theme

"What Has Been and Needs To Be Done?"

Questions for Discussion

1. Do we now have the technical knowledge required to control or prevent air pollution?
2. Is the available knowledge being used effectively?
3. What needs to be done further, and by whom?

Engineering Control of Air Pollution

Dr. Charles E. Lapple
Stanford Research Institute
Menlo Park, Calif.

Engineering in air pollution involves two general aspects: (1) an evaluation of the need for and the extent of control measures; and (2) the economic application of control measures, either at the source or in the field. It is in the evaluation phase that engineering ties in very closely with all the other aspects of air pollution, such as aerosol, argricultural, chemical, instrumental, meteorological, medical, legal, and public relations.

Engineering as practiced in air pollution is basically similar to engineering in manufacturing operations. The greatest difference lies in our inability in many cases to assign a specific rational value to the quality of air. Some aspects, such as nuisance and irritant effects, depend heavily on subjective considerations. Even such aspects as toxicity, while superficially amenable to quantitative description, involve a subjective consideration in that any finite concentration of contaminant may be injurious to some small fraction of the population. Thus, our standards for air quality must of necessity be somewhat arbitrary, based on a judgment which attempts to weigh considerations of public relations, moral responsibility, and public temperament. It is through the medium of public temperament that the question of economics arises, since ultimately the public, knowingly or unknowingly, directly or indirectly, will foot the bill. By the same token, our standards of air quality will be changing standards governed by what the public wants and is able and willing to pay for. The minimum standards will, of course, be dictated by considerations of public health, the maximum, by esthetic considerations.

It is the purpose of this presentation to outline exactly what is involved in engineering the control of air pollution in a broad sense. However, before any specific control measures can be engineered, it is necessary to answer the questions, "What are we dealing with?" and "What do we want the equipment to do?" Perhaps it would be more precise to say that this is the first step in any engineering program.

Types and Characteristics of Air Contaminants

The manifestations of air pollution can be summarized as health and safety effects, economic effects, and esthetic effects. Health and safety effects involve toxic action on humans, animals, or vegetation. In this category are also irritant effects such as choking, coughing, eye irritation, and reduced visibility of sunlight, all of which must be considered as at least potential health or safety hazards. Economic effects involve corrosion of equipment and buildings; soiling of paints, fabrics, or decorative finishes; maintenance of equipment or furnishings; reduced productivity, etc. Esthetic factors include appearance or odors.

From the standpoint of engineering control, however, it is more convenient to classify air pollutants as either gaseous or particulate, as outlined in table I. The attributes of control equipment are more directly related to differences along these lines than to differences in the type of field manifestations. Vapors, the gaseous phase of materials normally present as liquids or solids, are included in the gaseous category.

From the standpoint of control measures, as well as of field manifestations, the characteristics of gaseous contaminants that are most important are those associated with the chemical and physical characteristics of the specific gaseous contaminant. With particulate contaminants, on the other hand, the important characteristics in control engineering are usually mechanical in nature, and are more directly related to the size of the particles than to their composition, although the latter may be important in specific instances. It is for this reason that particulates are frequently characterized by their size, usually expressed as some characteristic dimension or diameter of the particle. The most common unit of length for specifying size is the micron, defined as 1/1000 millimeter or 1/25,400 of an inch. For the sake of visualization, the human hair is normally 50 to 100 microns in diameter. Table II gives the size of some common particulates and other reference items.

Gaseous contaminants.—Gaseous pollutants include such common materials as sulfur dioxide, nitrogen oxide, chlorine, carbon monoxide, fluorine, hydrogen fluoride, hydrochloric acid, volatile hydrocarbons, and many others. The effects of such gases can be either direct, as in toxic effects due to fluoride, or indirect, as in the chemical action of nitric oxides on some hydrocarbons to yield irritant reaction products. In general, gaseous contaminants will not manifest themselves as an esthetic nuisance other than as odors, which are normally due to vapors of specific compounds, usually organic, such as mercaptans. Gaseous contaminants in plant effluents usually are present in concentrations of less than a few tenths of a percent. A common order of concentration is a few hundred parts per million, which would correspond to roughly an ounce of contaminant in a roomful of air. Detailed data on gaseous contaminants may be found in the literature.[1,2,3,4,5,6]

Particulate contaminants.—Particulates may consist of either solid or liquid particles. Very small particles (less than 5 microns diameter) usually arise from the condensation of a previously volatilized material. Such particles are commonly called a fume or a mist, depending on whether they are solid or liquid particles. Larger particles arise from some mechanical process, such as grinding or atomization, and are called a dust or a spray. Most particulate contaminants manifest themselves as a simple nuisance (economic or esthetic effects). Some, such as fluoride salts and acid mists, however, may exhibit specific toxic effects related to their chemical composition.

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[1] Johnstone, H. F., "Properties and Behavior of Air Contaminants," Industrial Medicine and Surgery, 19, 107-115 (1950) March.

[2] Kay, K., "Air Pollution Review," Anal. Chem., 29, 589-604 (1957) April.

[3] Kirk, R. E., and Othmer, D. F., "Encyclopedia of Chemical Technology," vol. 5, pp. 646-662, 1950; vol. 7, pp. 83-106, 1951. Interscience Publishers, Inc., New York.

[4] Magill, P. L., Holden, R. R., Ackley, C., "Air Pollution Handbook," McGraw-Hill Book Co., New York, 1956.

[5] Manufacturing Chemists' Association, "Air Pollution Abatement Manual," Washington, D.C., 1951.

[6] McCabe, L. C., "Air Pollution," McGraw-Hill Book Co., New York, 1952.

The concentration of particulates in plant effluent gases is usually expressed in units of grains per cubic foot of air, where 7,000 grains is equivalent to 1 pound. A concentration of 5 grains per cubic foot is considered a high concentration and might be encountered in the untreated flue gases from a coal-fired boiler. Such a concentration would correspond to roughly 1 pound of particulates in a roomful of air. Plant effluents will more frequently run in the range of a few tenths of a grain per cubic foot, corresponding to roughly 1 ounce of particulate in a roomful of air. By way of comparison, the air one usually breathes would contain less than one one-thousandth as much particulate matter. The literature contains extensive data on the nature and concentration of particulate contaminants from various sources.[1 2 3 4 5 6 7 8 9]

Evaluation of Control Requirements

The first step in any control program is the assessment of the nature and quantity of pollutant involved. This can be done either by estimation based on prior knowledge of the operation in question, or of related operations, or by field measurements in the case of existing operations. It is in this area, as well as in the province of remedial equipment performance evaluation, that measurement techniques become very important. From the standpoint of engineering, one of our great current shortcomings rests in the lack of particulate measurement techniques which are both rapid and reliable.[10 11] In the case of gaseous contaminants, the greatest problems lie in the measurement of very low contaminant concentrations, especially where hydrocarbons are involved or when a simultaneous particulate phase of a similar compound is present, as in the case of fluorides.

As the second step in a control program, it is necessary to determine or estimate to what extent cleanup is required. Where contaminant control is dictated by economic considerations in terms of lost product, this estimate is relatively simple. Where control is dictated by air-pollution considerations, however, such requirements may be difficult to assess. In some cases legislative requirements provide a direct basis. In other cases it may be possible to apply known tolerance data to estimate permissible emission rates in terms of local meteorological conditions. This may become exceedingly difficult where other plants in the area are emitting a variety of contaminants simultaneously. It is actually the intent, though not necessarily the accomplishment, of legislative requirements to balance out such complex situations and provide a practical working basis for assessment. This is an exceedingly difficult problem because of the many intangibles involved and is one area where considerably more investigation is required.

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[7] First, M. W., and Drinker, P., "Concentrations of Particulates Found in Air," Arch. Ind. Hyg. and Occupational Med., 5, 387–388 (1952).

[8] Mine Safety Appliances Co., Chart No. 1500–1: The Concentrations of Materials in the Air; Chart No. 1500–2: The Sizes of Airborne Contaminants; Chart No. 1500–3: Limits of Particle Size Measuring Equipment, Pittsburgh, Pa.

[9] U.S. Atomic Energy Commission, "Handbook on Aerosols," GPO, Washington D.C., 1950.

[10] Lapple, C. E., "Elements of Dust and Mist Collection," Chem. Eng. Prog. 50, 283–287 (1954), June.

[11] Lunde, K. E., and Lapple, C. E., "Dust and Mist Collection—A Critique on the State of the Art," Chem. Eng. Progress, 53, 385–391 (1952), August.

Types of Control Measures

Table III summarizes all the possible types of control measures. The most obvious procedure is to so alter the operation or process as to reduce the amount of contaminant generated. The potentials along these lines are specific to each operation and are intimately linked with the economics, physics, and chemistry thereof.

The second most obvious control measure is to remove the contaminants from the effluent gases. This involves the installation of so-called control equipment. Equipment for controlling gaseous contaminants is usually different from that for controlling particulate contaminants, because of the great differences in the relative characteristics of the two types of contaminants. Occasionally it is possible, by proper design, to have a single piece of equipment control both gaseous and particulate contaminants. The variety of available control equipment will be discussed later.

Whether or not a contaminant is objectionable depends on its concentration at ground level of inhabited locales. Thus one means for alleviating a potential pollution problem is to so emit the contaminant that it is diluted with atmospheric air to nonobjectionable concentrations before reaching ground level. This is accomplished by emitting the effluent gases through a stack of appropriate height. Current knowledge of dispersion in the atmosphere is largely summarized in a recent Atomic Energy Commission publication.[12] It should be noted that a stack is useful for minimizing ground-level concentrations for distances up to a few miles from the source of the effluent. A stack, however, will have little effect on ground-level concentrations at distances remote from the plant, say, more than 50 times the stack height away.

Since the amount of atmospheric air mixed with a stack effluent is normally very large compared to the air or gas emitted from the stack, average ground-level concentrations are essentially independent of concentration of contaminant in the stack; they depend instead on the rate of contaminant emission from the stack, regardless of the concentration in the stack. Ground-level concentration also depends on the stack height and on the local meteorology. It is for this reason that there is usually no benefit from diluting the effluent gases before emitting them from the stack. However, instantaneous or short-term concentrations at ground-level may be many hundred times the average ground-level concentrations and may depend on the concentration in the stack. Our knowledge on this score is entirely inadequate. It is for this reason that stack design as it is now practiced may be erroneous for purposes of odor control since odor sensations may be more directly related to short-term pulses of contaminant then to average concentrations of contaminant.

For large effluent gas capacities, stacks offer a relatively inexpensive control measure. When stacks alone are inadequate, they are often used in conjunction with contaminant-removal equipment, either to reduce the degree of cleanup necessary with the control equipment or to allow for periods of abnormal operating conditions.

The three general methods of control discussed above (namely, source control, effluent control equipment, and effluent gas dispersal) represent measures to be applied directly to a specific emission. There remains the possibility of control on a community basis in which a variety of intermingled emissions are involved. One approach in this category involves the zoning of various industrial operations in such a fashion that anticipated emissions cannot constitute a pollution problem in the area concerned, in terms of the standard of such an area. This is analogous to the zoning of residential and business areas. Another approach in the community category is the purification of air on a community basis analogous to the treatment of community water supplies. To date this approach has not been applied, although it may require more serious consideration in the future when, and if, air pollution extends over vaster areas as the result of jet propulsion, atomic power or warfare, space flight, and vastly expanded industrial capacity. The worldwide strontium 90 fallout resulting from testing of atomic and nuclear weapons is an example of the type of problem that may arise although, in this case, being of military rather than productive utility, it is amenable to solution by cessation of such activity. At the present time the closest approach to this type of solution is the conditioning of building-intake air, although even this is practiced on a restricted private level rather than on a community basis.

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[12] U.S. Atomic Energy Commission, "Meteorology and Atomic Energy," AECU Report No. 3066, GPO, Washington, D.C., July 1955.

Control Equipment for Gaseous Contaminants

Table IV summarizes the various types of equipment for removing gaseous contaminants from effluent airstreams.

Absorption.—The most common type of equipment involves absorption of the gaseous contaminant by another medium. The effluent gases are contacted with a liquid, usually water, in which the gaseous constituent is soluble or with which it reacts. The contacting may be done in a variety of equipment: (1) columns packed with such items as ceramic rings, pebbles, wooden slats, or grids; (2) spray chambers, in which the contacting is achieved by atomization of the liquid; (3) bubble- or sieve-plate columns in which a special geometric configuration is employed to insure contacting; (4) wetted-wall columns; (5) a variety of mechanical devices, both stationary and power driven.[3, 4, 5, 13, 14] For atmospheric pollution control, the most common are the spray chamber and the packed column. The liquid absorption method is usually applicable where the gaseous contaminant is present at concentrations of more than a few hundred parts per million and a liquid is available in which the gaseous contaminant is readily soluble. Solids may also be employed as an absorbing medium, although this is relatively rare. With solids it is necessary that the gaseous constitutent react with the solid and that the reaction product either flake off or be sufficiently porous to make the interior of the solid accessible. Calcium carbonate and calcium hydroxide

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[13] Lunde, K. E., "Performance of Equipment for Control of Fluoride Emissions," Ind. Eng. Chem., 50, 293–298 (1958) March.

[14] Perry, J. H., "Chemical Engineers' Handbook," 3d ed., McGraw-Hill Co., Inc., New York, 1950.

have been used to remove hydrogen fluoride vapors from large air volumes.[15] [16]

In all absorption operations the contaminant from the effluent gas is transferred to a liquid or solid phase. Unless the resultant liquid or solid phase either has a specific commercial use or can be recycled to the process, a liquid or solid disposal problem is created.

Adsorption.—All gases will adsorb as thin molecular films on solid surfaces to a greater or lesser extent. This is essentially the principle underlying adsorption as a control measure. In adsorption, the effluent gases are contacted with specially prepared solid granules comprised of porous particles with extensive surfaces. The solid materials are selected for the specific contaminant to be removed. Equipment for contacting may consist of either stationary, moving, or fluidized beds of these granules, through which the effluent gas must pass; or it may involve injection of such granules into the effluent gas and subsequent removal thereof. Usually, after the granules have accumulated sufficient contaminant, they are rejuvenated either by steaming or by heating to remove the adsorbed contaminant. This may be done batchwise within the contacting equipment, or continuously by removing the granules from the contacting equipment. The common gas mask is an example of an adsorption device. The adsorbent granules may lose some of their adsorbing ability by the accumulation of trace contaminants that are not readily removed in the rejuvenation process. The loss of granules in the exhaust gases and the attrition of the granules in handling may also be very important factors in the overall economics.

In air pollution, the application of adsorption devices is usually limited to the removal of organic vapors at concentrations of less than a few hundred parts per million. It may also be applicable to high concentrations if the recovered vapors have value; in that case, however, recovery is usually justified for reasons of process economics rather than merely air-pollution control. Practical adsorption systems are available for handling high contaminant concentrations (>1,000 p.p.m.), as in solvent recovery systems, and very low concentrations (<30 p.p.m.), as in air-conditioning applications. There is a lack of developed systems for handling the intermediate concentration range, which is of greatest concern in air-pollution control.

Combustion.—The exposure of organic materials to high temperatures in the presence of air or oxygen will result in a decomposition and transformation of the organic materials into relatively innocuous gases such as carbon dioxide and water vapor. This is essentially what is accomplished in combustion as a control measure. There is a balance between the temperature to which the gas must be heated to destroy the contaminant and the length of time the gas is exposed to the elevated temperature. The longer the exposure time, the lower the permissible temperature. However, a long exposure calls for larger, and hence more costly, equipment. For reasonable exposure times, temperatures in the range of 1,000° to 1,400° F. are usually required.

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[15] Anon., "Giant Fume Catcher Stops Fluoride Emissions," Chem. Eng., 65, 66, 68 (1958) February. No. 4.

[16] Gilbert, N., Hobbs, I. A., and Sandberg, W. D., "Absorption of Hydrogen Fluoride in a Limestone-Packed Tower," Chem. Eng. Prog., 49, 120–128 (1953) March.

Combustion involves relatively low equipment costs for the incinerative phase. However, fuel requirements for achieving the necessary temperatures are very high. To reduce fuel requirements, appropriate heat recovery or interchange apparatus can be used, but this again increases the capital cost.

In catalytic combustion, a material of special activating properties, and known as a catalyst, is installed in the combustion chamber. This catalyst permits the oxidation of the contaminant to proceed at a lower temperature than would otherwise be possible. The use of a catalyst thus reduces the fuel requirement but increases the capital investment. These catalysts are also subject to "poisoning" by trace contaminants.

The addition of a reacting chemical to the effluent gas stream can convert the contaminant to a relatively innocuous compound. Because of various other problems that are introduced, however, this approach to control has found little application. Probably the greatest area of application for chemical addition has been in odor masking. A chemical additive may reduce or eliminate an odor nuisance either by altering the odoriferous compound or by altering the physiological response of the olfactory nerves to the compound.

Miscellaneous.—Compression and refrigeration are possible gaseous contaminant-control measures. By compressing and cooling a gas stream, contaminants can be caused to condense out as a liquid phase, which can then be recovered from the gas stream mechanically. The same can be accomplished by refrigeration of the gas stream. Both of these methods, however, are prohibitively expensive and have been seriously considered only in very specialized applications, such as some associated with atomic energy.

Control Equipment for Particulate Contaminants

All particulate collection systems depend on subjecting the suspended particles to some force which will mechanically drive them to a collecting surface. The known mechanisms by which such deposition can occur may be classed as gravitational, inertial, physical or barrier, electrostatic, molecular or diffusional, and thermal or radiant. There are also mechanisms which can be used to modify the properties of the particles and/or the gas to increase the effectiveness of the deposition mechanisms. For example, the effective size of particles may be increased by condensing water vapor upon them or by flocculating particles through the action of a sonic vibration. Usually, the larger the particles, the simpler the control problem. To function successfully, any collection device must have an adequate means for continuously or periodically removing collected material from the equipment. It is not infrequent that difficulties encountered in this all too obvious step are responsible for the malfunctioning of an otherwise satisfactory collection system.

Table V gives a summary of the various types of particulate control devices categorized by structural or application similarities.

Extensive descriptions of specific devices are given in the literature.[3 4 5 14 17 18]

Gravity settling chambers.—In the simplest type of devices (not necessarily the least expensive), the velocity of the gas is reduced to permit particles to settle out under the action of gravity. Normally, settling chambers are useful for removing particles larger than 50 microns diameter, although with special configurations they may be used to remove particles as small as 10 microns.

Inertial devices.—These devices depend for their action on the greater inertia of the particles compared to that of the gas. The cyclone separator, which is typical of this type of equipment, represents one of the most widely used and least expensive types of dust collectors. In a cyclone, the gas usually enters a conical or cylindrical chamber tangentially and leaves axially. Because of the change of direction encountered, the particles are flung to the outer wall, from which they slide into a receiving bin or into a conveyor, while the gases whirl around to the central exit port. A large variety of configurations are available. For large air-handling capacities, an arrangement of multiple small-diameter units in parallel is often used to attain high collection efficiencies and to permit lower headroom requirements than would be possible with a single unit.

Mechanical inertial units are similar to cyclones except that the rotational motion of the gas is induced by the action of a rotating member or fan. Some such units are designed to act as fans in addition to their dust-collecting function. There are also a wide variety of other units, many being called impingement separators. Most separators used to remove entrained liquids from steam or compressed air fall into this category.

Packed beds.—Units in which the particulate-laden gas stream is passed through a bed or layer of packing may be termed packed beds. This packing may be comprised of granular materials such as sand, coke, gravel, and ceramic rings or of fibrous materials such as glass wool, steel wool, or textile staples. Depending on the application, bed depth may range from a fraction of an inch to several feet. The coarse packings, which are used at relatively high throughput rates (1 to 15 feet per minute superficial velocity) to remove large particulates, rely primarily on the inertial mechanism for their separating action. The fine packings, operated at lower throughput rates (1 to 50 feet per minute superficial velocity) to remove relatively small suspended particles, usually depend on a variety of deposition mechanisms for their separating effect. Packed beds are usually limited to collecting particulates present in the gas at low concentrations, because of a gradual plugging due to particulate accumulation, unless some provision is made for removing the dust, as by periodic or continuous withdrawal of part of the packing for cleaning. Depending on the application and design, collection efficiencies with packed beds will range widely (50 to 99.999 percent).

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[17] Friedlander, S. K., Silverman, L., Drinker, P., and First, M. W., "Handbook on Air Cleaning," U.S. Atomic Energy Commission, Report No. NYO-1572, AECD-3361, GPO, Washington, D.C., 1952

[18] Stairmand, C. J., "The Design and Performance of Modern Gas Cleaning Equipment." J. Inst. Fuel (London), 29, 58-81 (1956) February.

Cloth collectors.—In cloth collectors, the dust-laden gas is passed through a woven or felted fabric upon which the gradual deposition of dust forms a precoat, which then serves as a filter for the subsequent dust. These units are analogous to those used in liquid filtration and represent a special type of packed bed. Since dust accumulates continuously, the resistance to gas flow gradually increases. The cloth must, therefore, be periodically vibrated or flexed to dislodge accumulated dust. Cloth collectors, sometimes called bag filters, range from the old-fashioned bag house to the heavy-duty units with automatic gas cutoff valves and bag shaking or cleaning at timed intervals. A wide variety of filter media is available. Cotton or wool sateen or felts are usually used for temperatures below 212° F. Some of the synthetic fibers may be used at temperatures up to 300° F. Glass and asbestos or combinations thereof have been used for temperatures up to 650° F. For special high-temperature applications, metallic screens and porous ceramic or stainless steel have been employed. Collection efficiencies of over 98 percent are usually readily attained with cloth collectors, even with very fine dusts.

Scrubbers.—In this category are all units in which a liquid, usually water, is used to assist in the particulate collection process. An extremely wide variety of equipment is available, ranging from simple modifications of corresponding dry units to permit liquid addition to those specifically designed for wet operation only. When properly designed for a given application, scrubbers can give very high collection efficiency, although the mere addition of water to a gas stream is not necessarily effective. For a given application, collection efficiency is primarily a function of the amount of power supplied to the gas stream, either in the form of gas-pressure drop, water pressure, or mechanical energy. With scrubbers it is important that proper attention be given to liquid entrainment separation in order to avoid a spray nuisance. Consideration must also be given to the liquid-sludge disposal problem.

Electrostatic precipitators.—In electrostatic precipitators, particulates are electrically charged by means of a corona discharge and caused to migrate to a collecting surface. The single-stage unit, commonly known as a Cottrell precipitator, in which the charging and collecting proceeds simultaneously, is the type generally used for industrial or process applications. These units normally employ direct current at voltages ranging from 30,000 to 100,000 volts. The two-stage unit, in which charging and collection are carried out successively, is commonly used for air-conditioning applications. These units also employ direct current, ranging from 5,000 to 13,000 volts, and involve close internal clearances (one-quarter to one-half inch). Electrical precipitators are capable of high collection efficiency on fine particles. Collection efficiency of a given unit is directly related to capacity, and installations are usually designed for a collection efficiency in the range of 85 to 99 percent. In design, special attention must be given to the problem of gas conditioning to obtain satisfactory electrical characteristics. The reentrainment of collected material as flocs in the exhaust gas, a phenomenon known as snowing, is another problem worthy of special consideration to avoid a possible accentuated nuisance or vegetation damage problem.

Air filters.—In this category are included all units used to eliminate very small quantities of dust from large quantities of air, as in air-conditioning applications. While units in this class actually fall into one of the previous classes, they are given a special category because of wide usage and common special features. In this category are viscous-coated filters and dry filters. These are actually a form of packed bed and are frequently known as unit filters, available as standard packaged units from a large number of manufacturers. The domestic furnace filter is an example of a viscous-coated unit filter. Automatic filters, provided with continuous and automatic cleaning arrangements, are available in both the viscous-coated and dry forms, as well as with electrostatic provisions.

Miscellaneous equipment.—Acoustic or sonic vibrations imparted to a gas stream cause particulates to collide and flocculate, to form larger particles that are more readily collected in conventional apparatus. This principle has been employed, but has had extremely limited application because of economic and other practical considerations. In thermal precipitation, suspended particulates are caused to migrate toward a cold surface or away from a heated surface by the action of a temperature gradient in the gas stream. This principle has found extensive use in atmospheric sampling work. It is unlikely that either sonic or thermal precipitation will find much application as atmospheric pollution-control measures.

Selection and Design of Control Equipment

The selection of gaseous control equipment is determined primarily by the concentration and chemical nature of the contaminant. For particulates, it is controlled mainly by the concentration and the particle size of the contaminant. In both cases, the required degree of cleanup required will be a major, if not controlling, factor. There are usually a number of secondary factors which must be considered, such as possible product recovery, continuity of operation, materials of construction, etc. These are not usually of prime importance in the selection of feasible equipment for a given application. They do, however, play a major role in the choice between possible alternatives and in the detailed design.

Gaseous control equipment.—Principles governing the design of gaseous control equipment are discussed in one of our references.[14] The basic information necessary for the design of absorption equipment is fairly well developed. The major gaps in knowledge along these lines exist in the performance of spray-type contactors. For adsorption at the higher contaminant concentration levels where recovery is normally justified, there is a reasonable background of knowledge. However, at lower concentration levels, the available knowledge is very meager. From the standpoint of air-pollution control, there is also a dearth of information concerning combustion processes.

In general, absorption will offer the more likely solution for controlling inorganic gaseous contaminants and may be applicable to other gases at the higher concentration levels. Adsorption is the likely solution for organic vapors and odors and possibly other gases at very low concentration levels. Combustion is usually indicated for organic contaminants, either where economic absorption or adsorption processes are not available or where the fuel requirements can be supplied by the contaminant itself or by other waste products.

Particulate control equipment.—The general principles governing the selection and design of particulate control equipment are discussed in several sources.[5 10 14 17 18] Although there are numerous data on the performance characteristics of specific equipment in specific applications, there are few generalized performance criteria, due primarily to inadequate equipment evaluation techniques. As a result, current design practice relies heavily on judgment, especially judgment on the basis of precedent or on the basis of random tests of a specific prototype unit. Seldom is an air-pollution installation given the searching economic comparison or scrutiny given to a product or process development. The approach, all too frequently, is to aim at any solution, not the most economic solution. In part this is due to a lassitude on the part of design engineers to assimilate an adequate background in this field. This lassitude, in turn, reflects the widely scattered sources of information and shortcomings in dissemination and coordination of what basic information is available.

Dispersal equipment.—Rational bases for stack design from the standpoint of dispersal are available.[12] These bases, however, are still inadequate in many respects. They do not provide an adequate basis for assessing dispersion under atmospheric inversion conditions, which may be a major factor in determining localized pollution levels. They are also fairly idealized in that they do not adequately allow for variations in wind speed and direction insofar as average downwind concentrations are concerned; nor do they permit prediction of short-term or instantaneous ground-level concentrations, which may be an important factor in odor control. The dispersion and distribution of coarse particulates (>10 microns) in the atmosphere from both man-made and natural sources is also an area in which knowledge is inadequate. Small particulates (<10 microns) behave essentially like gases insofar as atmospheric dispersal is concerned.

Cost of Control Equipment

Although the nature of the problem and the degree of cleanup required are important factors in the overall cost of a pollution-control installation, the single outstanding factor in cost is the volume of effluent gases to be handled. The quantity of contaminant usually has a negligible effect on capital cost although it may affect operating cost. Depending on type, pollution control installations cost from some $0.10 per cubic foot per minute of effluent air handled for the simplest air cleaning systems to some $10 per cubic foot per minute for installations involving heavy-duty equipment or special materials of construction. Installations usually run in the range of $0.50 to $2 per cubic foot per minute. Thus, to obtain a fast first approximation as to how much capitalization might be involved in a particular application, one might use a rough figure of $1 per cubic foot per minute, recognizing, of course, that this may be off by a large factor in any specific case. It is also apparent from this that, from an air-pollution standpoint, effluent air volumes should be reduced to a minimum to keep down capital costs. By the same token, many an existing installation could be operated more efficiently if the system were tightened up insofar as air in-leakage is concerned. This is especially critical in electrostatic precipitation systems. Older systems should also be reexamined for performance in the light of present-day operation. In many an operation, successive small capacity increases have resulted in total effluent air volumes far in excess of those for which the control system was originally designed. This usually means that, not only may the control equipment be operating less efficiently, but the total load of contaminant entering the control equipment will be increased, the net effect being a radically increased contaminant emission rate in the gases being discharged to the atmosphere.

Critical Requirements for Further Knowledge

The following will summarize briefly the areas in which the need for further knowledge is critical in terms of the broad engineering requirements. It should be emphasized that this summary is in terms of areas of technical interest and no attempt has been made to include specific equipment development needs for particular industries or operations. In almost every industry and operation, there is, of course, a need for specific control-equipment developments aimed at providing satisfactory and/or more economic control measures.

Control equipment for gaseous contaminants

1. Development of more economic construction for absorption equipment for handling low contaminant concentration, high-volume, effluent gases.

2. Basic performance characteristics and criteria for spray-type absorbers.

3. Adsorption characteristics when dealing with low concentrations of contaminants.

4. Basic performance characteristics of combustion or oxidation processes.

Control equipment for particulate contaminants

1. Development of adequate equipment evaluation techniques.
2. Basic performance characteristics and criteria for all types of particulate collection equipment.

Stack dispersal equipment

1. Dispersion characteristics of the atmosphere, including the effects of inversion conditions and topography.

2. Effects of variation in wind speed and velocity on average ground level concentrations.

3. Short-time or instantaneous ground-level concentrations as related to meteorology and stack concentration and emission rate.
4. Dispersion characteristics when dealing with coarse particulates.

General

1. Basic criteria for evaluating allowable emission rates in consolidated industrial areas. These are also required for purposes of rational legislation.

2. Evaluation of principles of deposition, retention, and uptake of both gaseous and particulate contaminants on surfaces and vegetation.

In addition to the above requirements for additional knowledge, there is also a great need for more dissemination of existing knowledge in a consolidated and critically coordinated form.

TABLE I.—*Types of contaminants*

1. Gaseous:
    - a. Gases (e.g., sulfur dioxide, nitrogen oxides, hydrogen fluoride).
    - b. Vapors (e.g., hydrocarbons).
    - c. Odors (e.g., mercaptans).
2. Particulate
    - a. Solid:
        - (1) Fumes (e.g., iron oxide, soda, silica).
        - (2) Dust (e.g., fly ash, cement).
    - b. Liquid:
        - (1) Mist (e.g., sulfuric acid, nitric acid).
        - (2) Spray (e.g., carry-over from towers; overspray from paint booths).

TABLE II.—*Approximate size of some common items*

Item	*Size, microns*
Diameter of human hair	50–100
Powerplant fly ash	5–100
Pollens	15–50
Atmospheric fog particles	2–50
Bacteria	1–10
Sulfuric acid mist	0. 5–10
Tobacco smoke	0. 2–1
Wave-length of visible light	0. 4–0. 7
Wave-length of X-rays	0. 001–0. 01
Diameter of large molecules	0. 005

TABLE III.—*Types of control measures*

1. Source control (process control).
2. Effluent gas treatment (control equipment).
3. Effluent gas dispersal (stacks).
4. Community action:
    - a. Zoning.
    - b. Treatment.

TABLE IV.—*Types of control equipment for gases and vapors*

1. Absorption.
2. Adsorption.
3. Combustion:
    - a. Incineration.
    - b. Catalytic.
4. Chemical:
    - a. Alteration.
    - b. Masking.
5. Miscellaneous:
    - a. Compression.
    - b. Refrigeration.

TABLE V.—*Types of control equipment for particulates*

1. Gravity settling chambers.
2. Inertial separators:
    - a. Cyclones.
    - b. Mechanical (power driven).
    - c. Miscellaneous.
3. Packed beds.
4. Cloth collectors.
5. Scrubbers (liquid).
6. Electrostatic precipitators.
7. Air filters.
8. Miscellaneous equipment:
    - a. Sonic.
    - b. Thermal.

Criteria for Selection of Methods of Air Pollution Control

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The rational approach to the control of atmospheric pollution in any specific area is based on two fundamental precepts: (1) reasonable use of the atmosphere must be recognized and accepted for the disposal of airborne waste materials, and (2) pollution of the atmosphere as a result of its use for the disposal of waste materials must be controlled sufficiently to prevent a nuisance or a detrimental effect on health or property.

The atmosphere has long functioned as a satisfactory acceptor of emitted wastes. With increasing industrial activities, it is logical to consider the atmosphere as one of the many natural resources which are being and should be used to the technical and economic advantage of any specific area. While employing the atmosphere as an acceptor of waste materials, the concentration of contaminants in the environment of the receptor must be limited to levels low enough to prevent damage to property and to prevent obnoxious or unhealthful conditions.

The occurrence of excessive pollution concentrations will depend upon the nature of the air-polluting materials, sources of emission, total amounts released, transport and dispersion of contaminants, and the nature of the specific effect. The mere existence of a pollutant in the air or the presence of a source of emission does not indicate that the atmospheric capacity for the disposal of pollutants has been exceeded and that an air pollution problem exists.

In developing the criteria to be used for the application of control equipment and techniques, the nature and scope of the air-pollution problem must be clearly understood—generally it is characterized by its complexity.

This complexity arises from the variation of the character of the contaminants discharged, from the diversity and intermingling of the industrial and community sources within large urban areas, and from the influences of topography and weather upon the distribution and concentration of the contaminants within the atmosphere.

Further complexity arises from the variation of effects of these contaminants upon the receptors, that is, upon man, animals, vegetation, and property. Effects may be local in nature, influencing only a small area immediately surrounding a single source or small group of sources, or they may be areawide, influencing an entire region. These effects are manifested in many ways, but are usually considered as reduction in visibility, health effects including eye irritation, damage to property including corrosion and soiling, nuisances, damage to vegetation, and injury to animals. In addition, many authorities point out the probability of long-term health effects to man, which to date have not been fully appraised.

The majority of foreign substances discharged into the atmosphere by the activities of man combine in effect to produce air pollution. These contaminants may be classed as aerosols or gases. Aerosols are the solid and liquid particles generated by combustion processes, mechanical action, and chemical reaction. Depending on the chemical composition and size distribution of these particles, aerosols are considered as being of major significance in influencing visibility, damage to property, and injury to animals and, at least under present status of knowledge, of lesser significance in effects on health and damage to vegetation. Gaseous contaminants are believed to be significant in relation to health effects, damage to property, damage to vegetation, and nuisances.

Pollution sources tend to be grouped at centers of population—around sources of raw materials, power, and transportation. This grouping results in a concentration of sources within a given area, but due to the topography and meteorology of the area the pollutants are widely dispersed, in many instances crossing municipal, county, State, and even national boundaries. A local air-pollution area must, therefore, be considered not in terms of political boundaries but in terms of that area affected by the same complex of air-pollution sources.

Each air-pollution area is unique. While some sources of contamination are common to all, there are many sources which are localized and nonuniform in occurrence. Further, the amounts of contaminant emissions vary from source to source, and the capacity of the atmosphere as an acceptor of waste materials varies with the topography and meteorology of any specific area. Finally, the susceptibility of the air-pollution area to a given contaminant varies, depending upon the population distribution of the various receptors, that is, man, animals, vegetation, and property, within that air pollution area.

A cursory evalution of the air-pollution control problem would tend toward the establishment of concentration limits for pollutants at the source which would be universal for all air pollution areas. Such an approach is invalid both technically and economically since it would require all areas to meet the degree of control required for the most susceptible area. Further, pollution concentration at the source in itself is not an acceptable measure for evaluating source effect. This factor becomes significant only when related to all of the variables which determine the pollution concentration in the environment of the susceptible receptor, such as gross rate of emission, topography, and meteorology.

However, a minimum control limit, that is, a baseline above which pollution concentration is not tolerable under any condition, should be established. Such a limit must consider two factors:

a. The degree of control for any source independent of other sources of pollution within the community must be such as to prevent obvious damage to property, including corrosion and soiling, obvious damage to vegetation, obvious injury to animals, and obvious detriment to health.

b. The limit of control thus established for each industry, for the air-pollution potential in the entire area, must be such that it would prevent from the combined source within the area serious damage to property and vegetation, serious injury to animals, and permit no detrimental effect on health under the most adverse weather conditions possible within the area. Such maximum limits of tolerance must be continually revised, based on new knowledge or significant changes in the area affected.

An adequate evaluation of pollution sources is obtained only by relating them to the effects produced in the environment for each specific air-pollution area.

The engineering approach to air-pollution control is, therefore, to limit at the source the amount of pollutants discharged to the atmosphere, such that the concentration of these pollutants in the environment from all sources will be sufficiently low to prevent detriment to health and property or the occurrence of nuisances, but at the same time allow the atmosphere to function usefully in its capacity as an acceptor of emitted wastes.

A rational approach for control at the source is not only dependent on the effects produced by these sources within the area under consideration, but as well upon both the technical and economic feasibility of effecting adequate control at the source.

All sources must be considered and evaluated individually. For many operations data relative to the character of the contaminant and adequate methods of control are available.

However, in many cases engineering studies are necessary to determine the operating characteristics of the system. Such evaluations generally include all or a part of (1) review of available source data, (2) source sampling and laboratory analysis to obtain the contaminant characteristics, (3) calculations to establish the control requirements, and (4) pilot plant work to develop the required control, if such is indicated.

A high degree of control at the source, however, is not always feasible, at least within the economic capabilities of the specific area. It must be recognized that the costs of source control are borne indirectly by society, but that the costs of the effects of air pollution in the environment of any air-pollution area are borne directly. Successful application of control at the source must, therefore, depend on the sagacity of the compromise between cost and the desired end.

DISCUSSION

William C. Galegar. Is there any attempt being made at this time to catalog these various engineering controls and assemble an index that would be made readily available to those of us who do not have access to all the information that exists in these many publications?

Dr. Lapple. There are a number of references that attempt to do that. These papers are being reprinted. So there will be a list of references. Some of the common ones are AEC Air Cleaning Handbook and the MCA Manual on Air Pollution Control. There is a recent text on air pollution by McGraw-Hill. And there is Perry's Handbook. The main problem with those is that they don't go anywhere near far enough. What we need is a more critical coordination of information. All that these sources do is briefly summarize some of the things that are known, but they do not go into the detail of evaluating known information to tie down specifically what we know, what we think we might know, and what we don't know, and present it in a summarized form for us. That involves considerably more work than has been devoted to any of these projects both timewise and dollarwise, and that is what is most critically needed.

Mr. Rose. There is a publication under preparation now by American Petroleum Institute that has the objective for which Dr. Lapple has expressed a need. It is a critical evaluation of the various types of control methods and how they can be applied and their proper application. I think in part this text may be an answer to your problem.

(Unidentified). Mr. Rose mentioned that it would be well to have maximal limits of well-known contaminants. Are any such limits established?

Mr. Rose. No. I believe, however, that you misunderstood my presentation in that I said there should be a maximal control tolerance established above which pollution concentration is not tolerable under any condition, even though many areas may require a still lower one, depending on their own particular needs so far as topography, meteorology, and the effect on the receptor are concerned. Such maximal limits have not been established yet.

Economic Aspects of Engineering Control (1)—Oil and Chemical Industries

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The oil and chemical industries have long been acutely aware that the control of the discharge of air pollutants requires large expenditures, not only from the standpoint of capital for control equipment but for the day-to-day operation and maintenance of this equipment. It has become regular practice to recognize these costs in figuring the payout of new processes contemplated for installation.

It should be apparent to control officials and particularly to the general public that the out-of-pocket costs of control, which in many cases are sizeable indeed, must be recovered by industrial plants in the prices of their products just as are their other costs of doing business. The public must pay the bill. Ineffective and unnecessary controls should be carefully avoided and industrial plants should be allowed time to work out the most economical and effective solutions to their air pollution problems.

Oil refineries and chemical plants, which when built were remote from residential areas, are being gradually surrounded by new housing developments and other industrial plants. Industrial operating practices which over a large number of years have caused no complaint from an air-pollution standpoint are becoming increasingly unacceptable. Because of this development high cost revisions to old processing equipment have been necessary. In some cases these revisions have been combined with modernization steps which have resulted in reasonable payout. However, more frequently there has been little or no payout for these installations.

In some cases the cost of air-pollution control steps has been so high as to warrant abandoning the process and installing new, more modern equipment which does not produce the offending pollutants. An accurate estimate of the true cost of abatement is impossible in such instances and the payout of the new plant may be calculated as being long or short, depending upon the basic assumptions of the individual doing the calculating.

Early this year The Oil and Gas Journal conducted a survey to learn what oil refiners in the United States were doing to control release of air pollutants. The survey showed that during 1956 and 1957 refiners had expended about $46 million and that during 1958 about $20 million would be spent. It may be well to take a brief look at how this money has been and is being used.

A modern oil refinery is composed of a series of complicated processes providing many potential sources of air pollutants. These may be grouped for convenience as (1) Odors, (2) Smoke and Particulate Matter, (3) Hydrocarbons, and (4) Sulfur Compounds.

Since odors are usually caused by release of relatively small amounts of malodorous vapors, there is little or no payout for collection systems, scrubbers, precipitators, etc. for controlling these release. Many refiners have found that odor levels may be greatly improved at low cost by simply adopting principles of good housekeeping in their plants.

As large consumers of fuels, oil refiners must be fully aware of the economic advantage of maintaining efficient nonsmoking combustion conditions in furnaces. It has been standard practice at refineries to burn waste gas, using simple open-end pipe flares which have caused considerable smoking. These are rapidly being replaced by smokeless flares of various types, which usually cost $50,000 to $200,000 each and for which there is no monetary return. Operating and maintenance costs may be substantial.

Extra-tall stacks to dissipate products of combustion are being installed at costs considerably above those of normal stacks. Recently a new refinery spent $230,000 of extra capital to extend stack heights.

Equipment for controlling the loss of particulate matter from catalytic cracking units is very expensive if extremely low levels of solids must be maintained in the regenerator gases. There is no payout in recovering catalyst which is so fine that it cannot be reused in the process.

Relatively few refineries have a fly ash problem but where a problem exists the cost of remedial steps is usually out-of-pocket with no offsetting credits.

In recent years, particularly in the Los Angeles area, hydrocarbons have been considered as a major air pollutant. Oil refineries have been required to install floating roofs on low vapor pressure gasoline and crude oil tanks and to take other steps to prevent loss of hydrocarbon vapors to the atmosphere. Such facilities have long been used by the oil industry and have been installed on a payout basis where the Reid vapor pressure of the gasoline or oil has exceeded about 7 pounds. Below this vapor pressure, floating roofs or vapor recovery facilities on tanks, loading racks, sumps, etc. will not, in most cases, reduce gasoline losses by amounts which will make their installation attractive.

The Oil and Gas Journal survey showed that refineries in the Los Angeles area spent over $6 million during the past 5 years to control tank vapor losses, in conformance with the Los Angeles Air Pollution Control District regulations. Few of the installations, which included floating roofs, vapor recovery, and vapor balance equipment on tanks, were economically attractive.

Large amounts of money have been spent by refiners for waste heat boilers on catalytic cracking units and on fluid cokers. These boilers, which cost from about $400,000 to $2.5 million each, burn carbon monoxide and hydrocarbons from the catalytic cracker regenerator or coking unit. These installations may have a fair payout.

Reduction in the release of sulfur componds has required large expenditures by the oil industry. The facilities which recover sulfur compounds from refinery gases and convert them to elemental sulfur or sulfuric acid yield a fair return on the investment in some cases, depending upon recovery conditions, size of the plant, sulfur prices, etc. It has been estimated that in the United States about 1,600 tons per day of sulfur is being recovered rather than being discharged to the atmosphere as sulfur oxides. During the past 5 years about $8 million has been spent for sulfur recovery facilities in the Los Angeles area. These facilities recover sulfur compounds equivalent to about 600 tons per day of sulfur dioxide.

A survey of 35 oil companies showed that these companies had spent about $17 million for control of sulfur compounds over the past 3 years. For the collection of hydrocarbon vapors and their combustion or recovery these companies reported expenditures for the 3 years of about $29 million.

A large oil refinery, built recently on the east coast, spent about $7½ million more for equipment than would normally have been spent if air-pollution control had been ignored.

The oil and chemical industries have spent large amounts of money on research to obtain answers to air-pollution problems. No reasonably reliable estimate of these costs is available for the chemical industry. For over 10 years the oil industry has carried on an extensive research program to learn what causes the hazy, eye-smarting community air-pollution condition in Los Angeles called smog. This and other programs of the American Petroleum Institute, the Western Oil & Gas Association, and numerous individual oil companies give an estimated total of $1 million per year being spent by the petroleum industry on air-pollution research.

The time allowed for this presentation does not permit greater discussion of the details of economics of control in the chemical industry. They are quite similar to those outlined above, and control is exercised in general by using much the same types of equipment and procedures as General Hull mentioned yesterday. The Manufacturing Chemists' Association has estimated that the cost of air-pollution control in the chemical industry on a company basis totals about 1 to 1½ percent of all production costs. This includes amortization of investment for equipment, operation, and maintenance.

Actual dollars spent represent a very poor indication of achievement in air-pollution control. Much too frequently, oil refineries and chemical plants have been required to spend large sums to meet arbitrary limits in regulations which are not backed up with technical data that give reasonable assurance of benefits commensurate with costs. Air-pollution-abatement results in such cases may be insignificant and small indeed in comparison with benefits from relatively small outlays for process alterations and for the training of plant personnel in good housekeeping.

It is quite common for an industrial plant to be asked by a representative of the public or by a Government official, "What have you spent for air-pollution control during the past year, or 5 years, and what do you expect to spend next year?" There is no connection whatsoever between the answers to such questions and air pollution. A plant which was well designed when built may operate free of air-pollution complaint for 5 years without any capital expenditures for control. On the other hand, a less carefully built plant or one where new processes have been added may find it necessary to spend large sums each year to achieve comparable or less control of air pollutants.

My remarks on the economic aspects of engineering control in the oil and chemical industries have, of necessity, been quite general. Actually, each plant in these industries is made up of many individual processes, and in most of them air-pollution control is involved. Industry technologists have demonstrated their ability to develop effective control methods and management has shown its willingness to pay any reasonable cost.

Economic Aspects of Engineering Control (2)—Fuels Industries

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Earliest known energy of the world was supplied by man and animal; later we find the advent of the water wheel as a source of energy; in 1850 the steam engine became a reality, and in 1900 electric transmission appeared as energy by wire.[1] Each of these developments had its part in the creation of today's mammoth industrial society of the United States, which is still growing, and each increased the trend toward concentrating these activities in smaller and smaller areas. Today the total economy of the United States is dependent upon energy, and the economy of the world is becoming more and more dependent on energy as backward nations are finding uses for and demanding more and more goods. The growth of the air-pollution problem in this country and in the world follows the dependence of an economy on energy.

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[1] "Industrial Power Is Different," Mechanical Engineering, vol. 80, No. 11, November 1958.

Sources of Energy

As we know sources of energy today, they are the sun, waterpower, fission and fusion, waste fuels, and fossil fuels. Each of these sources is worthy of a lengthy discussion, but for our purposes today we will limit ourselves to comments on the more economically usable fossil fuels: coal, oil, and gas. Because of time limitations, it is necessary to focus on the one facet of boiler fuels used in commercial, industrial, and utility stationary plant installations.

Fuels Used to Supply Energy

The best information available indicates that the total energy supply in the United States for 1957 was the equivalent of 1.6 billion tons of coal, of which 32.1 percent was coal, 36.3 percent was oil, 27.7 percent was natural gas, and 3.9 percent was waterpower. When motor fuels are excluded, the percentages change to:

	Percent
Coal	37.5
Oil	25.8
Gas	30.1

Bituminous Coal Facts, 1958, National Coal Association, June 1, 1958.

Leading authorities state that: "Bituminous coal is the predominant fuel in the boiler-fired market * * *" and "Over the decades the predominance of coal is likely to increase * * *"[2][3]

The figures cited above are actual figures for 1957; the following table shows a projection to 1980:

	Total energy consumed, 1955 (percent)	*Projected 1980[1] (percent)*
Coal	30	27.8
Gas	27	24.2
Petroleum	39	45
Hydro	4	3

[1] Nuclear Energy and U.S. Fuel Economy, 1955–80, National Planning Association, Washington, D.C., July 1958.

The 1980 projection of requirements for energy is double that of 1955, or equivalent to 3 billion tons of coal. Of this total energy, boiler fuel consumption for these periods is found to be:

Percentage of boiler fuel to total energy consumed (calculated from tables):

1947	37.6
1954	42.8
1980[1]	40

[1] Nuclear Energy and U.S. Fuel Economy, 1955–80, National Planning Association, Washington, D.C., July 1958.

Distribution of Fuel Use

Reviewing statistics compiled on the 62 largest industrial cities of this country, we find:

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[2] Nuclear Energy and U.S. Fuel Economy, 1955–80, National Planning Association, Washington, D.C., July 1958.

[3] "King Coal To Reign Through 1975," Electrical World, May 26, 1958.

Twenty-one cities are located in areas where oil is the most economical source of energy for boiler fuel (coastal, gulf, and southwest cities).

Eight cities are located in areas where gas is the most economical source of energy for boiler fuel (central Rocky Mountain cities).

Thirty-three cities are in areas where coal is the most economical fuel (southeast, central, mid-northwest, and southern cities).

Comparing these cities by size of industrial capacity (based on employees in manufacturing industries for 1954), we find the percentages of industrial capacity using fuels as follows:

	Percent
Oil	46.5
Gas	4.9
Coal [1]	48.6

[1] Industrial Marketing, June 25, 1958.

Excluding imported oil, these figures become:

	Percent
Oil	0.5
Gas	17.6
Coal	81.9

Should imported oil be denied to this country for political or other reasons, the same 62 cities would probably aline as follows: 1, oil; 9, gas; 52, coal.

World War II dramatically pointed up this need for interchange of fuels and necessitated extensive studies for plant conversions. The impact of restriction of imported fuels should receive consideration leading to the building of multi-fuel plants.

The above figures show clearly that fuel economy for individual areas and the United States as a whole was established prior to the present demand for air-pollution control, and economics will be a strong influence on fuel use for years to come.

Air-pollution-control programs are designed to conserve a natural resource—air; however, they should not be considered, legislated, or enforced without surveys and due consideration for the conservation of another of our vital natural resources—energy expressed in terms of fuel. Economics will govern fuel use more strongly than legislation for pollution control and the artificial effect of fuel restriction.

Community demands for boiler operation clean-up by way of fuel change have a greater impact on local economy when applied to public utility plants than when directed to basic industries. The latter plants use fuel in the processing or reduction of products distributed nationally or internationally. The utility sells its product in the immediate area of production. Any increased cost for clean-up in the utility operation may be passed directly to the very citizens demanding the change. The same thing is true of the operation of apartments, garages, cleaning establishments, lime-production plants, etc.

Equipment design, maintenance, and operation are the important factors in clean fuel use. Mr. John D. L'Hote, supervising engineer, Board of Education, Detroit, Mich., states: "The answer to cleanliness in a building and to the elimination of smoke lies in good design and good operation rather than the fuel." [4]

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[4] "Coal vs. Gas vs. Oil for Heating Schools," School Planning, October–November 1956.

Fuel is a commodity given to our economy in a quantity and quality which it is our responsibility to use properly. Equipment design and application are the tools to reduce air pollution from boiler fuels to a minimum.

Air Pollution Potential From Fuel Burning

In the handling and burning of coal, gas, and oil, it is found that safety should be given equal consideration with air-pollution-control requirements. The safety requirements of each of the three fuels are in inverse relation to the air-pollution-control requirements. Safety or air pollution makes extensive controls on any fuel-burning equipment a requirement.

The pollutants from fuels are smoke, fly ash, oxides of sulfur, oxides of carbon, oxides of nitrogen, hydrocarbons, and moisture.

Smoke and carbon monoxide from all fuels are controllable to an acceptable degree by use of modern equipment with proper design, auxiliaries, and application. Fly ash can be reduced to a small degree by improving burning, but the usual procedure is to install a collector device, which may be inertial, filter, hydraulic, electrostatic, or sonic. Sulfur dioxide may be considered a collectable pollutant; i.e., there are methods available for reducing this effluent to the atmosphere;[5] however, they are limited experimental installations due to the economic burden placed on the fuel-fired equipment. An SO_2 removal device will cost $4 to $6 per ton of coal fired or the equivalent per gallon of oil fired, increasing the basic fuel cost 50 to 60 percent.[6] Oxides of nitrogen, hydrocarbons, moisture, and carbon dioxide play a large part in air pollution, and many people are concerned about them. To date, these pollutants are receiving attention through programs of investigation, but no recommended practices for control are available.

Economies of Control

Discussing those effluents that are commercially controllable, let us consider smoke and carbon monoxide. On a new plant, cost of good, acceptable control equipment of high efficiency and safety is small in comparison with the total cost, not more than 7.5 percent. There is usually no economic justification for not obtaining the best basic equipment with necessary auxiliaries and controls. Costs are minimized by proper fitting at time of construction, and returns in higher fuel-firing efficiency and reliability will pay back the additional cost.

On older plants, a different picture presents itself. Ofttimes, regardless of intent, plant physical characteristics may not allow economical changes. Space, contour, structure, age of equipment, and other considerations may establish unacceptable costs for plant changes. Older plants usually have a short life expectancy, which will not allow a reasonable amortization rate. Changes can become exorbitant out-of-pocket expense items. These costs may reach an amount equal to or greater than the original cost of installation of the unit if enough years intervene, and later higher costs of equipment cause the corrective measures to be more costly than the original.

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[5] Bureau of Mines Information Circular 7836, "Sulfur Dioxide—Its Chemistry and Removal from Industrial Waste Gases," U.S. Department of Interior, 1958.

[6] Private communication.

Fly ash collector application should be considered on an entirely different basis, and costs of such auxiliary equipment must be related on some economical basis to the total cost of plant installation. In this instance, regardless of cost, if the collector is installed with a new fuel-fired boiler, it can be amortized with the total installation. On the other hand, if the unit is added at a later date, it must be treated as an expense item and the sizable expenditures required are not looked upon by management with favor when no "payback" is evident.

Collector equipment should be applied with care, using that equipment best suited for the job and economically justifiable. On a small unit, a low efficiency collector at reasonable cost may be acceptable. As the unit grows in size, a collector of higher efficiency may be required, such as a high efficiency mechanical, hydraulic, or electrostatic unit. These increase in cost as the size and efficiency increase. Taking four sizes of units, ranging from 10,000 pounds of steam per hour to 1 million pounds of steam per hour (boiler ratings) we find:[7] [8]

Estimated cost of collector compared to cost of automatically fired boiler

	Unsatisfactory collector (Percent)	*Satisfactory collector (Percent)*	*Superior (Percent)*
Small unit	--	15	30
Medium small unit	13	20	40
Medium large unit	14	40+	--
Large unit	5	28	

These figures are cited only to show that collector costs may become excessively high in proportion to production unit if extensive control is sought, and that control may become unsatisfactory if only cost is a factor. The 40 percent figure for a satisfactory collector on the medium-large unit is caused by the change to a higher cost collector required by the method of firing on this size boiler unit. Evaluation of problems and standards of acceptance are basic considerations for air-pollution control, but economics should also be justified, if possible.

Conclusion

In conclusion:

1. Problem of air pollution increases as the economy of a people becomes dependent on energy.
2. Air is a natural resource to be conserved, but fuel conservation should be considered of equal importance.
3. Economics establishes fuel usage; the artificial forces of attempting to change fuel usage should be avoided in attaining air-pollution control. Equipment design, maintenance, and operation are all important in obtaining cleaner air.
4. Maximum reduction of air pollution from boiler fuels is most readily accomplished when the measures taken can be economically justified.

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[7] "What Can a Small Plant Do About Fly Ash?" Midwest Power Conference, 1949.

[8] "Just What Do Electrostatic Precipitators Cost?" Power Engineering, November 1956.

Economic Aspects of Engineering Control (3)—Land Disposal and Incineration

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When we are talking about land fill or incineration, I am tempted to paraphrase something that Bill Shakespeare wrote a good many years ago, but it may affect the quiet slumber of that gentleman. But to bury or to burn, that is the question, and really that is the question that is facing a good many communities today across the length and breadth of the United States.

It seems that many of the problems of community growth have appeared at the same time, and we find that problems in disposing of waste materials from communities have developed at the time air pollution, too, has become a problem.

Actually, in collecting and disposing of the solid waste materials from communities we find that we are dealing with a cost to the community which compares with the cost for delivering an adequate water supply, or with the cost of collecting and disposing of the sewage from the community. So we are dealing with something that has a definite economic bearing upon community activities.

We find that a good many of our major cities have found the compounding of their refuse-disposal problems coincident with air pollution. We could point to New York City, Los Angeles, San Francisco, and I think you have a number of others. In most of these communities we find that there has first been a use of the local land for burial purposes, and, subsequent to that exploitation of the local land, a turning toward incineration as a logical alternative.

Incineration as we usually think of it involves a large municipal-type structure, one which may result in an investment of several millions of dollars, but we do have incineration in some communities which is confined to more or less the backyard type of operation. Los Angeles was a prime example of that type of disposal up until this past year when, in October, a ruling was passed which forced abandonment of the backyard burning unit and the initiation in the Los Angeles County district of collection and disposal by common means of those wastes which had heretofore been burned by the residents in backyard units.

Los Angeles is just one example of that. To a lesser degree, other communities have utilized these small units operated by individual citizens and mostly without success, because the temperatures involved are not usually adequate. Usually, low-temperature burning units produce large particles and rather pungent odors, and, if they don't contribute to the general air-pollution problem, they constitute a nuisance to the neighborhood or local community.

The municipal plants are more what I have in mind this morning, those which will burn in the neighborhood of several hundred to as much as a thousand or more tons for a 24-hour period.

Now, we are talking about a lot of money when we are talking about units capable of burning 1,000 tons a day. New York City has one of the finest types of municipal incinerators and it cost between $4 and $5 million for a unit suitable to burn about 1,000 tons daily. The operating costs are no minor problem. The cost in New York City today are currently running around $3.50 per ton if we include the amortization charges.

These are sizable figures in an area like Los Angeles County where rubbish production runs in the neighborhood of 10,000 to 12,000 tons daily. So we are speaking about a lot of money in capital investment and a lot of money in current operating costs.

These large municipal plants are designed to operate at higher temperatures than those used by individuals in their backyards, but that doesn't mean they can operate without problems. They simply have fewer problems. These large municipal incinerators have fly ash problems, and they contribute oxides of nitrogen, aldehydes, and similar type compounds to the general atmosphere.

There have been rather restrictive limitations placed upon the use of these units, but usually in terms of particulate discharge. I heard a lot of talk about the odors, gases, and other types of material that might emanate from the stack of an incinerator, but I don't know of anyone having put a numerical value on what those limitations should be.

We speak about the total particle discharge to the atmosphere, usually in terms of so much per cubic foot. Preventive devices as outlined to you this morning might be used on municipal incinerators. As far as some means of removing the small amounts of minor gases that are discharged, probably nothing short of activated carbon filters would provide a perfectly clean discharge.

One approach that has been used by the air-pollution district in Los Angeles County is to test efficiency of large municipal incinerators when operated at the lowest feed rate. If you have an incineration rate of 1,000 tons a day, you might operate at the rate of 500 tons a day and see how well that works. In such a case there has been some improvement in the discharge. I think you can readily understand that this doubles the capital investment cost and raises the operational cost proportionately.

Some research has been undertaken on municipal units, not so much by the industry itself, but by universities and private research groups. I can think of some work done by UCLA, New York University, and Stanford Research Institute. These are groups that have worked on the problem of discharges from municipal incinerators.

In order to arrive at some sort of comparison in the use of municipal incinerators we have to have another method of disposal and that other method in the United States is land fill, or burying rubbish under controlled conditions. This involves laying the rubbish down in layers and packing it with heavy bulldozers and covering it with earth, packed tightly so as to protect it against winds, odors, rats, flies, and other types of nuisances. Land fill is without air-pollutional problems provided it is operated as I have just described. A burning dump or open deposition of rubbish is not a land fill. And if we are talking about land fills and comparing them to incinerators, we must consider land fill as being a system which has been engineered to protect against nuisances; the amounts of materials that are released to the atmosphere from a land fill are minor in nature. It could be dust if the area doesn't have proper moisture, but that would be minor. There might be some carbon dioxide and other products of decomposition which might rise to the atmosphere from the land fill, but these don't pose any sort of air-pollution problem, because they are not in large quantity.

We spoke about incinerator costs of $4 to $5 million for thousand-ton capacity. We have in Los Angeles County established land fills at a cost of about $1 million dollars for 1,000-tons-per-day capacity. These are not completely proportionate, but will give you a rough idea of capital investment.

As far as operational costs go, land fills we can operate at a price of $1 per ton and pay all costs, whereas the best operated incinerators are run in the range of $3½ to $4½ per ton.

Land fills might then seem to be the logical solution, because they don't pollute the atmosphere, and they are a lot cheaper to implement and operate. The big problem is that you don't always have the land where you would most like to have it.

Now, this has led many cities to abandon land fills and go to incineration. They run out of local land and there is only one alternative, they figure, and that is to burn. In Los Angeles we have transportation where local collection vehicles discharge to large trailers which haul in bulk units to land fills. In one case we are operating over a distance of 23 miles each way, and the additional cost of it is $1.80. We add $1.80 to the cost of hauling, and we have a $2.80 charge to reach a land fill 23 miles away. This is still cheaper by quite a margin than the cost of building and operating an incinerator. We have calculated, and our results now prove, I think, that we can haul a distance of about 50 to 55 miles in the large trailer units to remote land-fill sites and still come out on about a par with the cost for local incineration.

This means to us then, before we will abandon land filling as a means of disposing of refuse, that we will have to look around and find out whether or not there are places where we can continue to bury, even at those extended distances.

I don't know about all cases, but I think in many cases it will be found that there are places where land fills can be established and where the relatively inexpensive transfer and bulk hauling system can be used in such manner as to reach these more distant sites within costs that are competitive with the costs of local incineration.

DISCUSSION

Richard Carver. I want to ask Mr. Bowerman: have you considered the use of waste heat recovery in incineration?

Mr. Bowerman. Yes. We have explored instances where waste heat recovery has been practiced and found that it hasn't proved to be an adequate substitute for straightforward incineration without subsidy. One example that has proved consistently to refute that very statement has been in Atlanta, and I'm not prepared to explain why they have so successfully been able to recover enough of the waste heat from their incinerator to make it a paying proposition. But the case histories of a dozen or more installations where waste heat recovery has been practiced show that the fuel provided by rubbish is so indeterminate as to its calorific value as to make unsure or uncertain the rate of recovery. Consequently, you can't tie it in with normal power use or normal heat use.

Dr. **Elmer R. Kaiser.** What is the rate of recovery of metals, steel, and the magnetic metals from municipal incineration?

Mr. **Bowerman.** Again we are provided with the best example in Atlanta, where, I believe, the ashes are separated by means of a mechanical device so that the cans, which are only partially burned, are then saved and the iron is subsequently recovered. This is also done at a few other incinerators and it does in a way pay for itself. In most cases it will not reduce the total cost, but it will be a profitable venture in that it is self-supporting. It is not any moneymaking proposition, but if you want to save the metal, it can be done at about the worth of the metal itself.

Mr. **Brown.** I would like to ask Mr. Bowerman if he has experienced any difficulty with the land-fill refuse method in polluting ground water wells. We have had some aspects of that in Milwaukee.

In addition to that, what do you do for cover material in an area that freezes tight in the winter?

Mr. **Bowerman.** With respect to ground water pollution, because of the brevity of the presentation, that topic was passed over. However, that is an excellent point to consider, because ground water pollution will in some cases dictate the abandonment of the proposed land-fill operation. In California a few land fills have been studied in an attempt to determine what effect they have on underlying ground waters. Based upon those studies a Regional Water Pollution Control Board has established a rule that no land rubbish fill could be placed any closer to the ground-water table than 2 feet. No ground water can be invaded by the rubbish, and this is on the assumption, I think, which is pretty well justified, that there will not be such penetration by rainwater or other percolating water as to convey any of the byproducts of decomposition into the ground water itself.

To minimize any possible invasion of the land fill by surface water, we drain the surface of the land fill so the water cannot penetrate. We also seal the cover by compacting it with regular road-type compacting equipment.

As far as water pollution is concerned, this is a very important criterion and can't be overlooked. Each land fill would have to be studied with that particular aspect in mind.

Would you repeat your second question, please?

Mr. **Brown.** What do you do for cover material in northern areas where it freezes up pretty tight?

Mr. **Bowerman.** I'm glad to say that in southern California we don't have that problem, but Mr. Leo Weaver has studied it and I would like him to answer that.

Mr. **Weaver.** In 1949 and 1950 I was project engineer on a study conducted through the cooperation of the North Dakota Health Department, and in 2 years of operation there, we found that, under certain conditions, a land fill could be operated in such a climate. We ran it even through some of the January temperatures there when it went to 40 degrees below zero. I don't know about Milwaukee. It's a matter of local conditions and soil types. But it can be done. There are over 100 cities I have learned of since that time that have used this system.

To comment now on another matter, Dr. Lapple's statements this morning on techniques for rapid and accurate measurement of particulate matter were interesting. We have had many pleas to help some of our people who are trying to operate incinerators in municipalities because of this difficulty of measuring particulate discharge and we have taken what I hope will be positive action in trying to do something about this.

We have for the past year been working with the Armour Research Foundation to assist the American Public Works Research Foundation in initiating a project to develop an accurate and rapid method of identifying particulate matter discharged from municipal incinerator stacks.

The discharge of pollutants from municipal incinerators is a rather insignificant contribution to the overall problem, but the municipality is in a situation where it cannot very well try to enforce regulations when its own backyard is not as it might wish it to be. This is the reason for the importance we attach to this particular phase of the overall program. We contacted some time ago 34 municipalities. The response has been very revealing as to the importance these cities place on the problem of air pollution.

(UNIDENTIFIED). I was quite impressed with what Mr. Burroughs said about questionnaires from control officers. There are one or two members of my staff who spend almost all their time filling out questionnaires from air pollution control officers throughout the United States, and we have to do a lot of investigation to find out how much money we have actually spent for air-pollution control devices, what portion of it is actually controlling air pollution, and what isn't. Sometimes it goes beyond all reason. Why is it continued in about the same pattern? I can think of a lot of questions which would get to the point more quickly and be much more pertinent. I hope some of the originators will hear me and see if they can't design their questionnaires better.

What Needs to be Done in the Future (1)—Application of Present Knowledge

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A broad review of this topic inevitably leads one to the conclusion that there is widespread failure fully to exploit existing knowledge toward the realization of improved conditions respecting air pollution. We believe it is no exaggeration to state that abatement of the vast majority of disagreeable air-pollution situations does not depend upon the development of more engineering knowledge than we now possess.

The most difficult problems are those in which there are serious differences between contending viewpoints as to the responsibility of a particular emission source for an objectionable air-pollution condition or situation. In light of the fact that every phase of human activity is responsible for some contribution to air pollution, it is obvously important to have an objectve basis for determining the *relative importance* of various sources and this in terms of the objectionable *effect*.

Logical consideration of the subject requires that we remind ourselves that air pollution is not a single entity and that the abatement measures applicable to a particular community must depend on the specific nature of the objectionable condition. In other words it is necessary to determine at the outset what particular air-pollution quality or qualities are primarily objectionable in any particular area. The principal effects (and for present purposes one should regard them as quite unrelated to each other) are the following:

1. Soiling of places of occupancy, by unsightly deposits of dark or light-colored dust; this is the phenomenon referred to as *dustfall*.
2. Reduction in visibility, illustrated in its more intense form by the Los Angeles problem and years ago in such plague-ridden coal-burning cities as Pittsburgh and St. Louis before the advent of important changes in domestic fuel. Occasional haze of lesser intensity is common to practically all of our large cities, usually not sufficient to cause any particular inconvenience but which might be esthetically displeasing to some people.
3. Large-scale prevalence of an eye-irritating quality, almost exclusively encountered in Los Angeles.
4. Small-radius nuisances characteristic of congested localities in all modern cities, typified by such things as odors from service industries, small-scale dust emissions affecting only those premises immediately adjacent to them, etc.
5. Low concentrations of sulfur dioxide in cities where no commercial agricultural production occurs.

If we were to consider air pollution in relation to agricultural activities we should have to expand this list somewhat, but it suffices for present purposes to confine our discussion to urban problems.

Such a classification as this is far from being an academic one, advanced only for logic in the presentation of the discussion. On the contrary it is of extreme practical importance because on it depends the design of regulatory operations of a local government and effective measures of a constructive nature. We pointed out that each of these five air-pollution effects is unrelated to the other and this slight exaggeration is of value for an understanding of this general subject.

It is to be noted particularly that this classification does not include any item covering damage to health and this is justified by the well-known fact that there is at present no evidence demonstrating a connection between air pollution and health (except in certain communities where a few well-known spectacular episodes have attracted wide attention in past years). It would be a mistake for anyone to conclude from this that health effects need to be demonstrated to justify measures for improvements. We are completely justified in demanding correction of conditions which are demonstrably objectionable and this is the basis on which the air-pollution problem must be attacked. It is unfortunate from an engineering viewpoint that no objective bases exist for the evaluation of these air pollution nuisances, because that fact complicates the problem of evaluating different situations and reaching conclusions concerning particular air-pollution situations. It does not follow from this that measurements of air-pollution intensity are lacking in significance. It merely signifies that since they refer ultimately to subjective criteria, interpretation of results must be based entirely on a relative scale.

Which of the air-pollution qualities enumerated above is of principal importance in most of our communities today? I suspect that the first one, soiling of premises due to the dustfall nuisance, is more objectionable to a higher proportion of the total population than any other single effect. This nuisance is the result of emissions to the atmosphere of coarse solid particles having high settling velocity. It is significant to note that, from an engineering standpoint, preventing the emission of coarse particles which are responsible for this particular type of nuisance is the simplest and least expensive of all the problems with which the air-pollution control engineer may be confronted.

If we are correct in our estimate of the dominant importance of the dustfall nuisance in most communities, then it is clear that a very dramatic improvement could be effected in most of our urban areas by the application of known gas-cleaning principles and at relatively small cost.

The implications of these statements constitute a rather serious indictment of present concepts and practices and it is appropriate to ask about the reasons for this state of affairs. The principal explanation is in the widespread preoccupation with the visibility aspects of air pollution.

The particles which are responsible for visibility effects are of an entirely different character from the coarse particles comprising dustfall. In all respects they are altogether different in their particle size characteristics (dustfall is caused for the most part by particles larger than 10 or 20 microns diameter and visibility effects by particles smaller than 1 to 3 or 4 microns). They are quite different also as to their origin; and the engineering measures that need to be applied also are of quite different character.

We have long been concerned with the fallacy so widely held that one's visual impression of a stack emission is somehow directly connected, as cause and effect, with ground-level dustfall phenomena, whereas, in fact, there is no certain relationship between the visibly apparent emission from a chimney-top and the degree to which one's premises are soiled by dustfall. In communities where dustfall is the principal nuisance, judgment concerning the stacks of its origin cannot be based on the visual appearance of the smoke or fumes issuing from them. In past years, when the wall- and ceiling-staining problem from coal smoke was paramount in many cities, the important sources advertised themselves, they were visible and evident, not only to the smoke inspector, but also to the heads of citizens' committees and to newspaper editors. This circumstance facilitated the smoke-control movements that have had the beneficial effects we now enjoy.

A visible stack emission may or may not represent a significant contribution to dustfall: in most cases it does not. It is, therefore, clear that the nontechnical public is no longer qualified to judge the relative importance of visible emissions as they are still doing in cities throughout the country. The origin of dust which only becomes visible when it is deposited on a window sill can only be determined by application of scientific techniques, a task which is often difficult.

I have chosen to dwell on the dustfall nuisance, here as well as on a number of previous occasions, because it seems to have received so little attention in comparison with the "visibility-aerosols," and because so much more could be accomplished by a concentrated attack on it in relation to the cost of control. I shall not dilute the force of this argument by added discussion on the control of fine particulates. We do, of course, recognize the dominant importance of the visibility nuisance in many communities.

I should like, however, to make one observation respecting the application of present knowledge to the control of fine particulate matter. Future research is quite likely to result in better methods, equipment, and processes for the removal of fine particles from gas streams and, probably, to do so at somewhat lower cost in some applications. It is, however, quite unlikely that such future developments will modify the cost of control equipment on such a scale that programs of air-pollution abatement will be much less difficult than they are at present. The hope for cleaner air, therefore, must not be thought to be dependent in any important way on new engineering developments of the future.

There is another principle that falls within the purview of my topic, application of which is of great importance in the control of air pollution. This relates to holding the line—preventing a significant increase in air-pollution levels as the years roll on. It will be inexcusable if in our present state of technological development we permit new installations to be made without superior auxiliary equipment to prevent the escape of undesirable pollutants into the atmosphere. Let us not pass these problems on to future generations as was done to us in the past.

I had occasion some time ago to review the proceedings of meetings of an old smoke prevention association that took place 30 to 40 years ago when pulverized coal firing was first coming to the attention of smoke-control officials. Their complete preoccupation with the problem of coal smoke apparently blinded them to the new fly ash problem. In this system coal is pulverized to a fine powder and blown into the combustion chamber to burn as though it were a gas. The unburned ash (fly ash) composed of extremely fine particles passes out the chimney with the gases to rain out onto the surrounding community. Many old installations are still operating without dust collectors and are responsible for serious pollution of some of our communities.

When we contemplate the magnitude of fly ash nuisance today it is indeed interesting to note the attitude of some smoke control officials toward this then-new system of coal burning, as brought out by a perusal of the printed proceedings of their conventions 30 to 35 years ago. It was regarded altogether as an important step forward because it permitted more effective combustion of the coal and more certain elimination of coal smoke and was received with enthusiasm. So important in the minds of all was the problem of black smoke elimination in those days and so relatively unimportant the control of dust, that very little attention was given to the potenial fly ash nuisance.

We read for example in the 1917 proceedings:

> The more finely divided the coal is the more readily it can be burned and under proper conditions *is absolutely smokeless.*

The matter of ash dust emission was raised during succeeding discussion and this answer appears:

> Some ash will go out the stack, there is no question about that, but in large installations where the plant is located near the center of town, some method of taking care of that ash may be necessary. . . .

In immediately succeeding years the question of ash discharge recurred but its significance was always minimized.

As more and more installations were made in the 1920's it soon became apparent that while the black smoke problem from industry had been waning, a new dust nuisance of major proportions had appeared from the pulverized coal development and public authorities were not prepared to cope with it.

I alluded in the beginning of this presentation to the various types of air pollution and to the fact that the proper control of an air pollution abatement program should be determined by the characteristics of a particular community. A carefully designed survey of a community to define its air-pollution characteristics can be of considerable value in planning its future program if it be decided that a program is desirable. The community survey should be carefully contrived, however, if it is to serve these objectives effectively.

I do not believe that any useful purpose is served by those surveys on which only a few days time is spent and whose reports merely summarize what everyone who lives in the community already knows. A mere listing of industries and other operations which contribute to air pollution does not provide community officials with any added understanding of their problem.

We must confess that we also take a rather dim view of community surveys costing $100,000 or more per year which result in acquisition of astronomical amounts of air analysis data having little relation to the practical question: what can this community do to alleviate its air-pollution problem?

We mention this aspect of the air-pollution problem because of our long-standing interest in the technique of community surveys and of a conviction that there has been a failure generally to face up to the need for direct and simple quantitative appraisals of a community's air-pollution characteristics. This subject, moreover, falls under the general heading of this paper because knowledge of effective survey techniques already exists ready for application to a study of any community's problem.

More than 30 years ago the industrial hygiene division of the Public Health Service made notable contributions to that field by leading the way in the development of quantitative survey techniques for appraisal of silicosis hazards. They properly judged that they could make a maximum contribution to the alleviation of dusty conditions by major emphasis on appraisal techniques research. The wisdom of this has been borne out by time.

It must be acknowledged that there has not been a corresponding recognition of the same need in the field of outdoor air pollution.

What Needs To Be Done in the Future (2)—Improvement and Development of Control Methods

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In undertaking to discuss control methods, it is my intention to cover primarily the air- and gas-cleaning aspects, since the elimination of the source of the contamination is a much more satisfactory solution, if it can be accomplished, than attempts to use the atmosphere as a diluting mechanism.

We may consider our needs in improvement and development of control methods as distributed into several basic areas. The area which is perhaps the most important is that of economics. Most of the other aspects impinge upon this area and we must, therefore, consider cost factors as paramount.

In the next fundamental phase, apart from the technical aspects, we have the educational aspects of air-pollution control. This implies that education is necessary at all levels. Education, like economics, is a basic factor because of its importance in providing a means of disseminating information already available to those who can make best use of it.

Areas for Investigation

The technical areas which need further investigation include:

1. New methods for handling fine metallurgical process fumes at high temperatures.
2. Methods for controlling acid mists and complex high vapor-pressure organic suspensoids.
3. New methods for recovering large-volume chemical effluents which are difficult to absorb or remove by contact washing. Nitrogen oxides, ozone, peroxide, are good examples.
4. New devices for combustion of low levels of gases which create odor problems and yet are too concentrated to adsorb on odor canisters but not concentrated enough for a major recovery system.
5. Continued studies on fundamental particle dynamics as applied to inertial separation, filtration, and electrostatic properties of particulates.
6. Continued investigations of the photochemical stability and physical chemistry of aerosols.
7. Fundamental studies on fixed and dynamic filters, with particular reference to life studies with a wide variety of aerosols.
8. Further studies on graded filter media for low loadings of air contaminants.
9. The development of temperature-resistant fabrics able to withstand 500° to 1,000° F. and still perform effectively as filter media.
10. Development of relationships from particle and equipment parameters which will enable the reliable prediction of performance

from primary dimensions and rapidly evaluated properties of the particulate material.

11. New economic methods for removing large volumes of sulfur dioxide from combustion gases.

12. Inexpensive methods for eliminating or destroying mobile combustion source hydrocarbon emissions.

TABLE I.—*Tabulation of needed research in air pollution*[1]

FIELD INVESTIGATIONS

PROCESS EVALUATION—EFFLUENTS

1. Compilation of characteristics and rates of effluent emissions.
2. Assessment of internal combustion engine emissions (urgent).
3. Determination of solid fuel process characteristics (urgent).
4. Appraisal of nitrogen oxide formation (urgent).
5. Relationship between transparent and opaque particulates.

PROCESS EVALUATION—MODIFICATIONS

General investigation of process modifications for pollution control.

CONTROL EQUIPMENT EVALUATION

1. Establishment of incinerator design criteria.
2. Evaluation of filter devices.
3. Evaluation of inertial separators.
4. Determination of electrostatic precipitator performance.

COMMUNITY SURVEY TECHNIQUES

1. Comparison of hourly dustfalls.
2. Acquisition of particle size data at ground level.

LABORATORY STUDIES

SOURCE SIMULATION

1. Preparation of test gases and aerosols (urgent).
2. Determination of properties, behavior, and methods of specification of aerosols (urgent).
3. Investigation of sampling methods (isokinetic).

PRINCIPLES OF GAS AND AEROSOL CONTROL

1. Studies of process modifications (urgent).
2. Fundamental studies on filtration mechanisms.
3. Development of high-temperature filter media.
4. Further studies on electrostatic phenomena.
5. Evaluation of droplet-type scrubbers.
6. Exploratory studies of less common mechanisms.
7. Fundamental treatment of gaseous contaminants (urgent).
    - (*a*) Absorption and adsorption of SO_2 and SO_3 at low concentrations.
    - (*b*) Oxides of nitrogen treatment and control.
    - (*c*) Conversion studies, including catalytic and noncatalytic combustion.

Economic Aspects

The problem of economics in pollution control is a basic one because industry can be penalized for its operations. If restrictive measures are imposed without reservation it could have a drastic effect upon our economy. The hope in any economic evaluation of an air-pollution problem is to obtain a solution which can be made without excessive cost and under conditions which do not suspend or interfere with operations for any protracted period.

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[1] Presented at Air Pollution Seminar, Cincinnati, Ohio. Published in Public Health Reports, vol. 72, No. 4, April 1957.

The most important approach is that which involves the recovery of a byproduct which is salable or can be returned to the process. This has been demonstrated many times in steel production. The recovery of material from a blast furnace has proved to be of substantial value. However, it has not been done without a long-range consideration of the initial cost of the equipment. Amortizing this cost against the recovery of the material has made the application reasonable but a definite time factor and capital expenditure are involved. It is easy to cite similar examples where the recovery of a byproduct has netted dollars and cents to industry and thus paid for control. The control of smelter waste gases to recover sulfur in the form of sulfuric acid is another case. The recovery of noble metals from smelter gases also has provided an economic return which offsets the cost of recovery equipment.

Not all economic aspects of air-pollution control on which needed development is desired, unfortunately, can be handled as simply. A large number of waste gases contain materials and particulates which have no real value at present or their value is so slight as to be insignificant in offsetting the cost of the control equipment. The burden of this assessment, of course, can be called the price of good community relations. Much equipment is installed on this basis, to the credit of industry in general. When the cost of such equipment, however, becomes so disproportionate in relation to the cost of the operation that it cannot be amortized over a reasonable period of time or cannot be justified on a basis of buying time in the community, then we must seek less expensive but still effective methods for the control of the contaminant. This emphasizes the need for less costly air-cleaning devices from both the capitalization and operating aspects.

Today we are approaching conditions in or near metropolitan areas when atmospheric dilution and dispersion of contaminants no longer can be easily done. The philosophy of building tall stacks in areas without a community nearby is reaching a similar status. Few locations are now available for heavy industry where ideal transportation, raw material, power and other economic factors justify moving a plant into an undeveloped area where it can avoid the community. The community encroaches rapidly, and today such development is more rapid than in previous years. There is a limit as to how high a stack can be built within reasonable economics. This limit, of course, must be balanced against the cost of the air- and gas-cleaning equipment to give similar control with less stack height.

Education

Education becomes a very important phase of all activity in advancing the frontier of engineering control methods for airborne contaminants. We need education at the lay level of citizens as to what constitutes an air-pollution problem and the degree of control which can be obtained within economic reason. We need education of young engineers at college level in order to provide them with basic information on techniques of air-pollution control and performance of equipment which can be applied to process effluents. They should get some perspective on aerosol technology. Solid-state physics is of major concern today, and I believe the finely divided solid state is of comparable importance. Particle technology is progressing and it is encouraging to see this related field developing. Problems of air and gas cleaning should be made available as a part of the curriculum of graduate mechanical and chemical engineering courses in more institutions than at present.

The engineer in training should be made aware of the differences in aerosol-collection mechanisms and their relation to particle technology. A significant body of literature now exists in the field of aerosol technology which can be presented to young engineers and chemists who will at some time in their careers encounter the problems of contaminants dispersed in gases.

Engineers now in the air- and gas-cleaning-equipment fields, particularly at the design level, but also at the sales department level, should avoid misapplications. These situations create a serious handicap to the control industry. In many cases industries are quite willing to cooperate and install air-pollution-control equipment but have been subjected to high-pressure sales approaches. Because of this they are faced with an aggravated and serious problem which forces them into an expensive educational phase.

Lastly, we need education of engineering and development personnel working in process design departments of many industries and consulting firms on aerosol technology. The importance of minimizing process effluent volumes and the proper enclosure of operations should all be integrated into their considerations with the proper emphasis. Too often the pollution aspects are not considered until an actual problem is created. Much expense can be eliminated by proper effort devoted to considerations in design or factors developed by pilot-scale operation.

Fundamental Research

The fundamental research aspects of air-pollution control by engineering methods is largely a problem of application of theory and empirical data already developed, as indicated by Mr. Hemeon in the previous paper. I do not wish to imply that, in considering air-pollution control or aerosol research devoted to its application, we have all of the knowledge we need at the present time. I have already listed several gaps in our technical aspects. A considerable amount of knowledge in fine-particle technology has been developed, however, and several fundamental filtration and other separation methods have been well defined.

More work is desired to yield data on new aerosols and their inherent properties. This is particularly the case in fundamental particle dynamics, electrostatic charge, and wetting. Removal of particles by aggregation, flocculation, and agglomeration remains a fruitful investigative area, at least as far as a practical measure for application in recovery of aerosols is concerned.

Unfortunately, considerable effort which has been devoted to research has not been applied because this knowledge is not in the hands of those who can apply it to practice. This is the same gap or lag between fundamental research and development. It is a restraining force, limiting application of fundamental research to engineering development in many fields. Inertia exists in the air- and gas-cleaning industry just as in others. More effort is applied toward adapting existing equipment to new problems than vice versa. The problem of education mentioned before becomes more apparent with these considerations.

Application of bag filters to airstreams containing particulates, but which also contain corrosive gases, is a good example. While the particulate might be removed effectively, the gas damages the fabric media in a short time. Immediately after such a situation an intensive search, which may be fruitless, is made for a fabric to withstand the gas or corrosive vapor and still permit the particulate material to be removed satisfactorily. The tremendous advance in fiber technology in recent years has been a great aid in solving such problems. Just how this condition can be remedied rapidly in terms of the existing state of the art is a difficult problem. Certainly, further education and dissemination of knowledge to those at the design and application levels will be of value. Applied laboratory research on effective simulation of the actual problem, based on reliable field evaluation, may often prevent this kind of situation. On the other hand, the time factor is often ignored and, while immediate failure may not be the result, fatiguing of materials will develop in practice. This, therefore, involves able research forecasting to anticipate possible ramifications which may develop in operation.

Research Work in Progress

Before concluding the subject of fundamental research aspects, mention should be made of work already in progress. Actually, some very basic investigations are being pursued in this country and abroad in the development of air- and gas-cleaning techniques. A major portion of this work is being done in educational institutions and by research foundations, but a significant number of contributions are coming from governmental and industrial laboratories. I believe it is correct that support for this research to date has been largely governmental, but contributions from nonprofit organizations such as the American Iron & Steel Institute, American Petroleum Institute, and the Western Gas & Oil Association and other groups has been substantial. The impetus from Government agencies in many cases has been because of military or defense aspects. For example, in the field of air and gas filtration the media developed under U.S. Army Chemical Corps and U.S. Atomic Energy Commission sponsorship are extremely useful contributions. Extension of these developments to industrial applications is already under way. The Public Health Service under Public Law 159 has been supporting grants, contracts, and their own research in air and gas cleaning.

As a final comment, I believe that industrial groups such as those already mentioned who have turned their attention to this type of activity, in which all members of an association or industry have mutual and common problems, should realize or already have realized the value of pooling efforts and supporting research and development on an industrywide rather than an individual company or corporation basis.

Mr. Brown. Is there anything you have knowledge of which is in the works and has some chance of successful application for the control of the nitrogen oxides?

Mr. Hemeon. We have some knowledge of work that the Air Pollution Foundation is supporting. There was some work done on catalytic decomposition of nitric oxide. There is work going on in this subject in Los Angeles now, largely devoted to the automobile problem. I don't think anybody has gone too thoroughly into powerplants and installations of that type, although there is some concern about them. Professor Haagen-Smit has done some work on this problem. I'm not completely familiar with it. He has published one paper describing some results.

Extent to Which Controls Have Been Utilized by Industry (1)—Chemicals

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The very nature of the chemical industry makes it imperative that intelligent attention be given to making the best use of air-pollution-abatement techniques. What are our techniques; how extensively are they used: what are the trouble spots; what abatement criteria should be used? These are the questions. Let us explore the answers.

We all recognize that the chemical industry is a vast, complicated manufacturing business. It is composed of over 12,000 plants spread throughout our country and engaged in a whole spectrum of processes, and in areas dissimiliar in population, topography, and meteorological conditions.

The active work in reducing air pollution has been going on for many years. Upon that foundation, the formation of the Manufacturing Chemists' Association has given stimulus to this important responsibility.

As one measure of abatement activity in the chemical industry, I find that they use about 20 percent of the bag dust collectors and catalytic combustion units, about 35 percent of the liquid scrubbers, and about 20 percent of all electrostatic precipitators. While these figures are certainly approximate, they serve as positive evidence that the chemical industry as a whole is serious in its objective of reducing pollution.

It is the philosophy of the chemical industry in general, on new construction, to arrive at solutions to pollution problems during the design stage. In fact, it is generally top management policy to be assured that this has been done before authorizing a project. Progressive management has put a premium on securing and maintaining good public relations.

Broadly speaking I would judge that existing air-pollution abatement equipment is adequate in most cases. There are problem areas of course, and I will mention a few of these later. However, the fact should be squarely faced that the most difficult problems in controlling atmospheric pollution are economic. According to the Manufacturing Chemists' Association, the chemical industry is currently spending 2½ to 5 percent of the total new plant investment cost for control of air and liquid wastes. This is a high price to pay for adequate control when you realize that there is no return on this investment.

Two examples will illustrate that the chemical industry is developing and applying new techniques:

1. Last year two chemical companies separately announced development of techniques for recovery of chlorine gas.
2. The other instance involves hydrogen sulfide and carbon disulfide gas. Both of these gases have very low odor detection thresholds. Where it is necessary to control these odors the carbon disulfide is absorbed in oil and the remaining hydrogen sulfide is converted to elemental sulfur by catalytic reaction.

It must be recognized that for a chemical company or plant to keep on top of its air-pollution abatement efforts, team play is required, plus an understanding of the problem at all levels of personnel. An example of applying this philosophy is the recent technique used at one chemical plant in keeping alert to its odor problem. Approximately 50 employees and their families, living within a 1½ mile radius of the plant, established a volunteer patrol. These people called the plant whenever they detected an odor thought to be of plant origin. The frequency of occurrence has been practically eliminated because of the recent installation of scrubbers.

In taking up problems confronting the chemical industry, one of the first logical questions is "what should the abatement criteria be for the industry," or for that matter, any group—industrial, commercial, or community? Where we set these values will determine how efficient the abatement equipment must be and the feasibility, both technically and cost-wise, of meeting the criteria. There are a number of factors, either singly or in combination, which could be the criteria—vegetation or paint damage, eye irritation, odor, visibility, dirt nuisance, and, of course, toxicity. Each chemical has its own scale of values for each of these characteristics. The factors controlling abatement design will vary depending on the chemicals, location of plant, and frequency of poor meteorological dispersing conditions.

Much could be said about each of these criteria and I might add that none are too precisely defined. Since odors are mentioned as the most frequent source of complaint for industry generally, I would like to make two observations which may throw light on the magnitude of the odor-control problem. The odor-detection level of many chemicals is exceedingly low. For example, if a volume of hydrogen sulfide the size of a golf ball were allowed to permeate the average home, most all members of the family would detect it. Secondly, we have probably all experienced the effect of "now I smell it—now I don't," which is due to the vagaries of turbulent wind currents. We have found that these momentary peak concentrations may reach 50 or even a hundred times the average concentrations we would breathe over a period of hours.

Should the ultimate consumer have to pay the relatively high cost of preventing an occasional odor which is only a nuisance and has no health or property damaging effects? After all, many of us will rush to turn on the kitchen exhaust fan to keep the odors of cooking onions from permeating the house. Thus, we expect, just as in the case of the chemical plant with its high stack, that the great outdoors will disperse this nuisance before it reaches the neighbors. While this dispersive action of the atmosphere is adequate, we occasionally know that the Joneses next door are having fried onions with their steak.

I would like to mention several other trouble spots.

1. One of the basic pollution problems is sulfur dioxide. Its principal source is from the fuels used to generate steam. It is one of the most widespread and costly control problems with which I am familiar. In many cases the chemical industry is turning to lower sulfur fuels as a solution. As regards the sulfuric acid manufacturers, they have long been in the market for a catalyst which will convert sulfur dioxide directly to sulfuric acid and which will not become poisoned after short use.

2. A breakthrough in flexible fabrics for bag collection is needed. The requirement is one which will withstand temperatures in excess of 1,000° F., resist acids, have low pressure drop, and collect the last 2–3 percent of the submicron-sized dusts at a realistic cost.

3. The fact that the appearance of a stack's plume is responsible for an increasing number of complaints suggests another area which needs investigation and clarification. Appearances are deceiving. The existence of a plume does not mean necessarily that the material is harmful or in fact that there is very much of it. Submicron-size particles contribute greatly to the visibility of a plume although the total amount of material may be very small. Likewise, a clear stack does not guarantee the absence of harmful materials, since many gases are colorless. In addition, I would like to call attention to two problems which, while not peculiar to the chemical industry, are probably more intensified for them than for any other industry.

Batch operations, that is, the starting and stopping of manufacturing facilities, is very prevalent in the chemical industry even though the trend is toward more continuous processes. The air pollution from this method of operation is nearly always difficult to control and usually defies conventional solutions. Its control is almost always more costly. I recall such a problem and its solution, which occurred a few years ago. Over 90 percent of the hydrogen sulfide and sulfur trioxide released in the batch operation occured in 4–5 minutes though the cycle is several hours long. These two pollutants were entrained in a total air flow exceeding a rate of 100,000 cubic feet per minute. A way was found to solve this problem. At the instant of release, the gases are literally drowned with water at a rate of 9,000 gallons per minute. I might add that this rate of water would supply a city of about 100,000 persons.

Maintenance in the face of chemical corrosion is a second problem. The waste gases from chemical manufacturing are such that the abatement equipment often requires high maintenance. An example of this with which I am familiar is a chemical plant which utilizes a number of scrubbers having pressure drops of 45 inches of water.

While these scrubbers are 90 percent efficient, many of the tiny uncollected particles deposit on the fan blades and unbalance them. Frequent shutdown is required to scrape away the material—a costly item, since it also requires shutting down the process.

I would like to take a moment to discuss the economics of byproduct recovery. It would be erroneous to say that there are no instances where recovery of valuable products defrayed part or all of the cost of air-pollution control. While publicity has been given to this, the fact remains that the value of byproduct recovery is dwarfed by the total chemical industry's costs for control. After all, the real objective of industry's control efforts is to assure safe and comfortable environments for workers and adjacent residential areas.

In summary, the chemical industry uses approximately 20 percent of the air-pollution control equipment sold. It supports air-pollution research as an industry—and as individual companies. Through recognition of the problem, the industry is actively searching for and perfecting control solutions to build into its new plants and to use in its older ones. Because of its understanding of chemical processes and reactions, the chemical industry stands in a unique position to solve its in-plant pollution problems. The industry must continue to keep the public informed of its accomplishments and its goals so that they, the public, will know the chemical industry is serious in its abatement responsibilities.

Extent to Which Available Control Techniques Have Been Utilized by Industry (2)—Iron and Steel

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In order to produce its 100-odd million tons of steel each year, the steel industry consumes over 100 million tons of iron ore. It comes from all over the North and South American continents and varies in composition from over 60 percent pure iron to less than 30 percent, and in particle size from large lumps to less than 1/8 inch. It consumes about 60 million tons of steel scrap picked up wherever it can be done economically, over 100 million tons of coal of increasingly more undesirable quality, over 30 million tons of limestone, and finally and very importantly, several billion tons of air. Our processes demand this air and cannot function without it. Yet air has no place in our final product and must therefore be returned to the atmosphere from whence it came. It is largely in connection with the return of this borrowed air that the steel industry has an air-pollution control problem.

The principal equipments used by the steel industry are: blast furnaces, coke ovens, open hearths, electric furnaces, and bessemer converters, to which must be added, particularly as of recent years, the sinter plants. Let us discuss them in proper order.

Blast Furnaces

The steel industry has added many protective devices to its blast furnaces in recent years. Bled blast furnace gas has been reduced or eliminated by installation of automatic gas pressure and automatic combustion controls.

There has been a material reduction of dust in blast furnace gas by the use of high-energy modern wet washers and/or electrostatic precipitators. These clean the gas before it is burned. A troublesome spot remains, namely the so-called blast furnace slips. These are caused by the fact that the charge inside the furnace sticks occasionally to the furnace walls. During normal operations this sticking is "corrected" by the occurrence of "slips." In other words, slips act as safety valves to prevent more serious damage.

There is no known method to eliminate blast furnace slips. They have been reduced substantially by improved practices. Also ore is being beneficiated in sinter plants, which when used in the furnace aids in preventing slips.

Operators are constantly experimenting and employing new and modern operating practices to eliminate blast furnace slips.

Sintering and Sinter Plant Air Pollution

Sintering over the past several years has become accepted as an integral part of the steelmaking process to a much greater degree than before. It is broadly a part of the larger problem of preparation of blast furnace raw material, which, although carrying with it an air-pollution problem of its own, has to some extent reduced the air-pollution problems of the blast furnace itself. As pointed out before, better feed preparation results in smoother furnace operation, with fewer slips and with lowered amounts of dust.

The industry is using a variety of gas-cleaning equipment at sinter plants, one combination being a bank of small-diameter cyclone separators followed by electrostatic precipitators. Wet scrubbers are also used. Individual variation in sinter feed and local operating conditions dictate the choice of equipment and materials of construction.

Coke Ovens

The escape into the atmosphere, from the coke plants, of coal dust and fumes has been reduced by washing the coals, installation of smokeless charging equipment, installation of self-sealing doors, improvement in the heating of the end flues, and installation of automatic self-lighting coke gas bleeders.

Electrostatic precipitators remove the tars and assure a cleaner gas for use in the mills.

Open Hearth

The gases leaving an open hearth furnace are at a temperature of about 1,600° F. and contain about 0.5 grain of dust per standard cubic foot of gas, with peak loadings in the neighborhood of 2 grains per standard cubic foot. Over half of the dust is less than a micron in size and a large part of this material has been measured at about 0.03 micron.

Because of the small size of the particles to be captured, mechanical cleaners such as cyclones are not effective. Precipitators, high energy scrubbers, or filters are required.

In four installations presently operating, waste-heat boilers have been used to reduce the gas temperature to about 500° F. and electrical precipitators have been employed to do the cleaning.

The first installation on four small cold-metal furnaces has proved to be exceptionally trouble-free.

However, three subsequent installations on large hot-metal furnaces have shown very serious operating problems, particularly as to efficiency.

In each case the contractor has, by suitable modifications, been able to lick the problem. However, this points up the fact that much remains to be known before cleaners can be installed with assurance of success.

Two additional installations will soon be on stream and we in the steel industry are anxiously awaiting the start-up time to determine whether the equipment manufacturers' latest designs contain the improvements claimed by them.

Because of the operating difficulties encountered with precipitators, as well as the high cost of these units, one company, following extensive pilot-plant studies, is now installing a high-energy scrubber on an open hearth. It is recognized that, although this scrubber has a high power requirement (about 700 hp. for a 200-ton open hearth furnace), the pilot plant showed many good features which could only be evaluated by a full-scale unit.

In addition to these efforts, American Iron & Steel Institute has sponsored a research project at Harvard to develop a new type of cleaner for the open hearth. The type chosen for development was a slag wool filter, with the wool made from steel mill slag. Two pilot-plant models have been evaluated at an open hearth, and a third, improved model is being designed.

Finally, engineering studies are underway to determine how it will be possible to fit these large cleaners in existing open hearth shops which were not originally laid out for the additions. This point may prove, in the end, to be one of the most difficult problems to be overcome.

Electric Furnaces

Electric furnace fume has been difficult to control from the beginning because of the awkward hood design required for a tilting furnace, the fineness of the fume particles, and the high temperatures generated. Recent tests show that grain loadings frequently reach 3 grains per cubic foot and the maximum found was 6 grains per cubic foot. Particle size analysis showed that 98.9 percent were less than 1.5 microns.

In recent years close-fitting furnace-roof-mounted hoods and water-cooled duct connections have permitted capture of the fume as it escapes the furnace. An even newer development has been the removal of the gas and fume directly from the furnace itself. In both cases, the temperature of the gas has been high and collection of the fume has been difficult. Electrostatic precipitation has been successful in some cases, but only after much preparation of the effluent.

The art of electrostatic precipitation is so little understood that any departure from the routine requires much trial and error in conditioning the gases so that the dust or fume burden may be precipitated. Temperature, humidity, etc., all must be adjusted within critical ranges before acceptable efficiency can be attained, and their good performance depends on careful supervision.

Cloth filtration, even though known to be suitable for fine fume collection, has never been applicable because of the high temperature involved or because of the high gas volumes (and consequent large bag house) resulting from the addition of the cooling air needed to bring the temperatures to roughly 275° F. The recent development of silicon-treated glass cloth and the use of "flexing" for coke removal instead of shaking may open a new path for fume control. Gas volumes are considerably decreased, as glass cloth can withstand temperatures of 500° F. and higher, and silicon treatment of the glass cloth allows the filter cake to be dislodged by a gentle flexing action which greatly prolongs bag life and decreases maintenance costs. Experience with this collector is limited, but there is much promise in the use of glass cloth in fume collection.

Bessemer Converters

In the bessemer process of steelmaking a suitable solution to the converter-fume abatement problem has not been found. Work in this country, as well as in Europe, on scrubbers, filters, packed beds, injection of steam, and ultrasonics, has been unsuccessful. Of these attempts, introduction of steam to the blown air reduces fume formation with reduction in scrap melting capacity. However, the turn-up and turn-down of the converter still presents a problem unsolved.

In order to remove the fume from the exhaust gases of the converter, it seems logical that the vessel should discharge into a hood or stack. Because the operation of the converter is controlled by visual observation of the flame and because of accumulations in the hood, the collecting dust must be some distance from the mouth. Due to air aspiration into the collecting system of a large magnitude at approximately 500° F., the air collection and cleaning equipment would be of such magnitude as to be economically unfeasible.

Research is under way at the Battelle Memorial Institute to study the mechanism of fume formation and its control.

From the consideration of these factors, the basic top-blown high-purity-oxygen process is receiving much attention from the industry. This process lends itself to hooding and fume collection, due to reduced volume of gases produced and fixed vessel position.

Basic oxygen plants installed in this country to date have utilized air-cleaning devices of several types: high-energy scrubbers, disintegrators, and electrostatic precipitators, with what appear to be satisfactory results, although operating problems are still present.

Miscellaneous

Finally there are a number of miscellaneous operations which deserve being mentioned, for instance, billet and slab heating furnaces. Much work has been done on heating furnaces to improve combustion by way of automatic control instruments.

Likewise, old-fashioned steam boilers have been replaced by modern high-pressure boilers equipped with electrostatic precipitators, and equally, the conversion from coal-fired steam locomotives and cranes to diesel power has proved to be an important stride forward in the reduction of air pollution.

Finally, by way of borrowing a thought from those who are battling the exhaust of the internal combustion engines of our automobiles, serious thought is being given to determine whether or not the unburned gases and smoke, which in many instances appear to be unavoidable in the function of soaking pits, can be rendered less objectionable by the use of catalytic afterburners.

The steel industry has studied, and is continuing to study, its problems in this field of air-pollution control and has made considerable progress toward the necessary solutions. Installations are proceeding in orderly fashion as knowledge is developed and as they become economically and technically practical.

Extent to Which Available Control Techniques Have Been Utilized by Industry (3)—Oil

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The oil industry organized a committee in the American Petroleum Institute in 1928 to study the air- and water-pollution problems of the industry and to assemble and develop the information needed to solve these problems. In the early 1930's the first edition of volume II of the API "Manual on Disposal of Refinery Wastes" was issued. This booklet discussed the sources of contaminating gases in a refinery, outlined the properties of these gases, recommended practices for control, and gave various data on control equipment, combustion, dispersion, etc.

Subsequently four new and expanded editions have been issued, the most recent being the fifth edition in 1957. This manual has been widely distributed in the oil industry and has been used extensively as a source of up-to-date information concerning air pollution.

The committee has grown to have a membership of about 60 engineers and chemists representing companies having over three-fourths of the refining capacity in the United States. The meetings of the committee are forums in which members exchange information on air-pollution problems and methods of solution.

The committee sponsors research projects at universities and other institutions, when appropriate, for obtaining information on specific air-pollution subjects. Recently a project was completed on cyclone dust collectors. At present the committee is having information assembled for publication on dispersion of gases and particulate matter from stacks and flares.

Through the activities of this group, information on available control techniques has been at hand as needs arise, and these techniques have been used extensively in the industry.

During the past 15–20 years air-pollution control in a refinery has become quite involved because many more products are being made, many new processes are being used, plants have been expanded, and available crude oil is, in general, higher in sulfur content.

Let us take a look at some of the control measures commonly used by oil refiners today. Smoke is seldom produced from a refinery in objectionable amounts and then only during unusual circumstances. Furnaces and burners are of improved and efficient design. Combustion conditions are controlled by instrumentation. More gas is being burned and liquid fuels are more uniform in composition. Relatively small amounts of solid fuels are being used and these are pulverized before burning. Smoke indicators, recorders, and various stack-gas analyzers are used extensively to help the operator maintain proper combustion conditions.

Waste gas flares have been a source of considerable smoke in past years. Refinery technology has greatly reduced the volume of waste gas, and most of the objectionable smoking flares have been replaced with smokeless type flares. These flares usually depend upon water or steam injection to give smokeless combustion.

The former practice of burning off refinery waste oil ponds at more or less regular intervals has been discontinued by most refineries. Today the oil is recovered and either burned smokelessly in an incinerator or waste-heat boiler or returned for reprocessing.

The great majority of refineries process crude oils of relatively high sulfur content. The crude oil itself may be rather high in hydrogen sulfide content but in addition, during the refining processes, a sizable percentage of the other sulfur compounds are converted to hydrogen sulfide. This compound is a malodorous, toxic gas. The gases driven off during crude oil distillation and during processing of petroleum fractions by cracking and hydrogenation may contain fairly large percentages of hydrogen sulfide. It has been common practice to use these gases as fuel, thereby converting the hydrogen sulfide to sulfur dioxide, which is dispersed into the atmosphere with the flue gases. Tall stacks are used in many refineries to insure that objectionable concentrations of sulfur dioxide will not reach ground level. Of course, the fact must be recognized that when liquid or solid fuels are burned the sulfur compounds in these fuels are likewise converted to sulfur dioxide and discharged with the stack gases.

Many refineries are controlling the discharge of sulfur dioxide at low levels by extracting the hydrogen sulfide from light hydrocarbon fractions and from fuel gases. Process waters which would release objectionable odors are stripped of hydrogen sulfide, using steam. The hydrogen sulfide recovered from these operations is sold to a chemical company or converted at the refinery to elemental sulfur and sold in this form. A recent survey by the Oil & Gas Journal revealed that in the United States about 1,600 tons of sulfur per day are being recovered instead of being allowed to escape into the atmosphere as sulfur oxides.

Today, catalytic cracking processes, which circulate hundreds of tons of powdered-clay-like catalyst hourly, are used extensively in refineries. Special equipment and handling procedures are necessary to prevent objectionable amounts of these catalysts from reaching the atmosphere. Vacuum systems protected by bag filters are frequently used for unloading the catalyst from shipping cars. Losses from the cracking units themselves are controlled with multiple-stage cyclone separators. Electrostatic precipitators are also being used.

While on the subject of catalytic cracking it should be mentioned that the catalyst regenerators of these units discharge carbon monoxide and traces of hydrocarbons in the stack gases. These gases are released high in the air and are at high temperature, giving excellent dispersion. To the writer's knowledge there has been no instance in which ground-level concentrations of these gases have reached objectionable levels. The gases from these stacks sometimes have a plume-like appearance which attracts attention. A number of these catalyst regenerators have been equipped with waste-heat boilers which consume the carbon monoxide and hydrocarbons and destroy the plume.

Techniques for controlling loss of hydrocarbons in refineries are well developed and are used broadly. Fire hazards and value of product have been of prime importance in setting the degree of control at a low loss level. Trace amounts of petroleum hydrocarbon in the air have no objectionable odor nor toxic effects. That refinery vapor losses contribute significantly to smog is highly questionable.

Hydrocarbon losses from gasoline tanks are controlled by the use of floating roofs or other type conservation roofs or, in many instances, tanks are connected to vapor recovery systems. To prevent evaporation losses it is becoming an increasingly popular practice to cover or partially cover separators used to recover oil from refinery waste water. Mechanical seals are employed extensively on centrifugal pumps to reduce pump gland leakage. In some areas vapor recovery facilities have been installed at tank truck loading racks. The recovered vapors may be burned or returned to gasoline.

Odor control is practiced widely by refiners. The careful handling and control of sulfur compounds as discussed previously contributes to odor abatement. Where mercaptans are recovered from gasoline-treating operations these are confined until shipped to a chemical company, or other purchaser, or destroyed in the refinery. In most cases they are oxidized as part of the gasoline-sweetening operation.

Malodorous air which has been used in oxidizing operations is incinerated by refiners to destroy the odorants and hydrocarbons. Refiners have spent much effort and money in cleaning up waste waters in the interest of water-pollution abatement. These efforts have greatly reduced odors from refinery sewers.

Spent sulfuric acid is usually returned to chemical companies for reprocessing. Caustic soda containing mercaptans, sulfides, phenols, and cresylic acid is frequently sold to outside chemical companies. Some refineries neutralize spent caustic soda with spent sulfuric acid. This is done in closed tankage with released vapors being incinerated.

Barometric condensers in which water is contacted with petroleum vapors have been almost all replaced by surface-type condensers. Odors were caused when the water was passed over open towers for cooling.

Last, but far from least, mention must be made of the importance given to good housekeeping in the oil industry in controlling air pollution. It is fully recognized that large expenditures for the best available control equipment will not insure satisfactory results unless personnel responsible for its operation are thoroughly educated in their jobs and understand the importance of clean air. Awareness of these principles and a cooperative plant personnel have contributed much to the oil industry's success in air-pollution abatement.

Extent to Which Available Control Techniques Have Been Utilized by Industry (4)—Electric Power

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In the burning of fossil fuels under the large steam-generating boilers common in the electric power field, there are still two fields where, by current opinion, much research and development is still needed if such plants are not to contribute to air contamination. On the other hand, three developments have been perfected to the point where, in construction designs of recent years, a high degree of clean air operation has been achieved. These three developments have been long in coming, have been costly both for their development and now for their adoption, and represent an achievement in accelerated engineering progress typical of the electric industry in the past 10 years.

1. Accomplished

To cover first the three fields of known progress, progress where near trouble-free designs and operation are consistently achieved:

(*a*) *Smoke—Unburned hydrocarbons from coal and oil.*—No stack now serving a modern central station boiler shows old-fashioned smoke these days, except possibly under emergency load conditions, and then for only a few moments. Smoke, of course, was until a generation ago the sum total of air pollution, and "smoke prevention" is still in the descriptive title of many municipal bureaus. By "smoke" is meant those black, unburned hydrocarbons, arising from incomplete combustion, particularly of volatile portions of the fuel. Agglomerations of such black components into flufflike particles of "soot" are still common from small domestic and commercial heating stoves or furnaces. ("Soot and fly ash," a common phrase used by laymen, is a grossly inaccurate one. "Airborne dust and cinders" might be better.)

The solution of the black smoke discharge problem has been achieved by development of fuel-burning equipment and furnaces which lead to complete combustion of oil or coal by adequate air at the right place intimately mixed with the fuel.

The near elimination of smoke from modern utility plants is not only a notable achievement from the viewpoint of a clear atmosphere, but is of great importance in that current problem of the "compound X" irritant found in Los Angeles. Unburned hydrocarbons are still discharged from many forms of combustion furnaces and engines, and from evaporating sources.

(*b*) *Fly ash.*—By this is meant the cinder discharge associated with both stoker and pulverized forms of coal firing. The central station industry has standardized on pulverizing for modern coal firing, and now has achieved consistently high efficiency of removal of fly ash from its modern furnace chimneys. This has been a long, and expensive, program. The central station industry, in some years, has used 90 percent of the output of dust-collector manufacturers—these are mechanical collectors, electrostatic collectors, or the two in combination. Efficiencies of over 90 percent are now the rule, and over 95 percent has been achieved in favorable circumstances, such as high resistivity of the coal ash.

The cost of dust-collector equipment is great, representing 2 to 4 percent of the cost of the whole powerplant. It has been a great mechanical achievement; it has eliminated one source of atmospheric dust as a nuisance to urban life; it has required a significant economic contribution by the American people.

(*c*) *Stack design.*—Significant accomplishments have been reached as to stack height and nozzles for optimum plume-discharge velocity, and in other essentials of smokestack design, for a maximum of performance for the plant area and community. These developments have been brought on primarily through the use of elaborate wind-tunnel studies made at the design stage on models of plants, sometimes of terrain, and of various stack heights and discharge velocities. Sometimes the use of high velocity by restrictive nozzles at the stack top have been necessitated by rulings of the Civil Aviation Board calling for low stacks; where such limitations do not limit stack height, and where model studies of plant and analysis of terrain show the need, stack heights up to 750 feet have been designed and built for utility powerplants. Again this is an added economic load, but is accepted under the philosophy that a good utility and a thriving community go together.

2. Problems Under Development

The utility industry, as must all industry if this country is to survive, must ever be conscious of the economic significance of its practices, as well as of its community responsibilities. This bears repeating. This country must protect itself from inordinate demands in the name of clean air when the demands arising emotionally, or even hysterically, are based on no true information and grow out of unsupportable "facts," where there is no knowledge of what is needed or how it can be accomplished, or any appreciation of the burden that we can place on ourselves by rash action. This precept must guide developments around each community's steam-electric powerplants.

Unsolved, or only partly solved, problems involve the more obscure, less tenable, almost imperceptible elements of stack discharge—elements on which there is only the vaguest hint or suspicion of their being objectionable, areas where known remedies frequently cause new troubles more severe than the original.

(*a*) *Sulfur.*—Vast research projects are underway by private industry on means for removing high portions of sulfur from coal. This could be economically significant for metallurgical coals, and in eliminating corrosion of coal-burning equipment. Its importance in clean air is only guessed at. Nevertheless, work is underway and more is needed on measurements of sulfur oxides discharged, means for removing sulfur from fuels (coal and oil), and even for reduction of sulfur oxides in flue gas. Again, there is no knowledge showing that sulfur in our urban air in the amounts normally encountered even approaches a nuisance level.

(*b*) *Nitrogen oxides.*—There are recent indications that steam boilers release some objectionable amounts of nitrogen oxides. Work is underway which shows how boiler furnace design can appreciably reduce nitrogen oxide formation. Here, again, the quantitative need, as well as the solution, require more measurement and knowledge.

Summary

In three highly significant areas leading toward a cleaner atmosphere, the steam-electric utility industry in its modern plants has made, sometimes at great cost, many developments which come close enough to perfection to say the job has been done. These are (*a*) the elimination, at all but accidental times, of smoke, i.e., the discharge of black, unburned hydrocarbons resulting from incomplete or arrested combustion; (*b*) installation and maintenance of high efficiency fly ash collectors on coal-burning stacks; and (*c*) the design of smokestacks for proper height and discharge velocity, basing design on elaborate wind-tunnel testing, and for maximum conformity to the atmospheric and aviation needs of the community. With these accomplishments in effect it is not at all unusual to have a power plant smokestack so nearly clear there is a question whether "the unit is on the line." Work and more knowledge of limits as well as feasible solution of sulfur and nitrogen discharge is underway. More work and knowledge is needed. No other fields are now known which involve the central station steam boiler in air pollution. Great progress and, indeed, near perfection is being reached on the old problems.

Extent to Which Available Control Techniques Have Been Utilized by Industry (5)—Automobiles

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Several investigators have shown that hydrocarbons and oxides of nitrogen react in sunlight to form ozone and smog irritants. Automobile exhaust gases contain both unburned hydrocarbons and oxides of nitrogen.

Certain urban areas have poor air circulation because of meteorological and topographical conditions which often cause air stagnation. In such areas a large concentration of automobiles may produce a significant tonnage of hydrocarbons and oxides of nitrogen.

It is also interesting to note that research to date on atmospheric reactions has indicated that certain air-pollution manifestations may be related only to certain specific hydrocarbons and that certain other hydrocarbons may have no effect at all in producing air-pollution manifestations.

Automobile Industry Approach to Problem

Several years ago the individual manufacturers in the automobile industry met informally under the auspices of the Automobile Manufacturers Association to investigate the problem of automobile exhaust and air pollution. It was recognized that one urban area in the United States, Los Angeles, had a severe air-pollution problem and probably required primary attention. Technical representatives of all the automobile companies then personally surveyed the Los Angeles problem and initiated a one-million-dollar-a-year industry research program.

From the initial analysis of the problem it was decided that the following areas of investigation would be pursued vigorously and concurrently, contrary to normal research programs, which follow an orderly succession of defining the problem, developing instrumentation, designing and building test prototypes, evaluating test prototypes, and repeating this cycle until the final solution is achieved.

1. It would be necessary to develop instrumentation for analyzing automobile exhaust gas in terms of ppm and pphm. Available instrumentation consisted primarily of the Orsat Analyzer, which measured CO, CO_2, oxygen, and nitrogen only as low as 1 percent by volume. The instrumentation needed to quantitatively detect the hydrocarbons in automobile exhaust gas did not exist, and would have to be invented and developed if we were to do any useful work toward eliminating hydrocarbons from automobile exhausts.
2. A study would have to be made to determine how people operate automobiles in terms of the percentage of time spent when the car is idling, accelerating, decelerating, and cruising; and values for the average cruising speed and rates of acceleration and deceleration would have to be determined for a large representative population of cars, so that the performance of an average car could be determined. For such a survey it was obvious again that new instrumentation would have to be designed and built.
3. Presupposing success in the development of instrumentation and analytical techniques for determining hydrocarbons and oxides of nitrogen during various engine operating cycles, it would then be necessary to conduct a full scale exhaust gas field survey, where a large representative population of cars could be tested in a uniform manner and an exhaust gas analysis obtained for each car.
4. By careful analysis of the traffic survey and field survey data, it was hoped to be able to define exhaust gas emission in terms of concentration in the exhaust and rate of emission, so that the total emission of these pollutants to the atmosphere could be determined for any representative car population.
5. It would be necessary to study the exhaust composition of cars as they are built and adjusted to factory specifications and also as they go out of adjustment due to lack of maintenance

and/or increased mileage, to determine whether or not a real difference exists, and if so, what steps could be taken by the manufacturer to reduce this difference and what steps could be taken by the car owner to keep his car maintained to a minimum level of hydrocarbon and oxides of nitrogen emission.

6. It would be necessary to conduct a thorough literature survey to pinpoint the knowledge existing in this area which would be of help to us.

Implementation of Industry Program

It was immediately recognized that in the area of determining exhaust gas composition the Coordinating Research Council was available to us, since both the automotive and petroleum industries who support the CRC were interested in determining exhaust gas composition. A Group on the Composition of Exhaust Gases was thus formed within the CRC and four panels established:

1. *Sampling and analysis.*—To develop the necessary instrumentation and analytical techniques for determining exhaust gas composition.
2. *Variables panel.*—To study the effects of fuel, lubricant, and engine variables on exhaust gas composition.
3. *Field survey panel.*—To conduct test programs in the field to determine the exhaust gas composition of representative car populations.
4. *Literature survey panel.*—To survey all existing literature and distribute the resulting bibliography to the membership of the Group on the Composition of Exhaust Gases.

Within the Automobile Manufacturers Association a Vehicle Combustion Products Committee was formed under the auspices of the Engineering Advisory Committee and it organized itself as follows:

1. *Induction system panel.*—To develop induction system devices to prevent unburned hydrocarbons from entering the engine exhaust system.
2. *Exhaust system panel.*—To develop devices in the exhaust system for removing unburned hydrocarbons in the exhaust.
3. *Traffic survey panel.*—To develop instruments and conduct a full-scale traffic survey in a representative car population to determine how people drive cars.
4. *Data analysis panel.*—To analyze all pertinent data as they become available and to keep the parent committee up to date as new data are developed.
5. *Carbon monoxide panel.*—To develop instruments and procedures for measuring carbon monoxide concentration in passenger compartments to help in the design and location of vehicle exhaust systems.
6. *Visible smoke emission panel.*—To aid in the development of enforcement techniques for identifying automobiles with excessive visible smoke emission.
7. *Exhaust systems engineering panel.*—To develop test techniques and criteria for evaluating exhaust systems location on the vehicle.
8. *Medical panel.*—To study health aspects of automobile exhaust.

Results

The sampling and analysis panel of the CRC, whose members come from both automotive and petroleum laboratories, has released a considerable number of reports dealing with both grab sample and continuous techniques for analyzing hydrocarbons, oxides of nitrogen, carbon monoxide, carbon dioxide, etc. Work is continuing in the sampling and analysis panel to refine the techniques for determining total hydrocarbons with the infrared analyzer. Work is also continuing under contract at the Bureau of Mines in Bartlesville, Okla., with funds supplied by the automobile and petroleum industries, to develop gas chromatographic techniques to identify specific hydrocarbons in automobile exhaust gas. Several laboratories are also working on the development of techniques for determining continuously oxides of nitrogen in exhaust gas.

The variables panel of the CRC has completed a study of engine variables and their effects on exhaust gas composition and has released a report dealing with this subject.

The field survey panel of the CRC has conducted two field surveys, one minor and one major, and has recently released a report on the results.

The induction system panel of the AMA accepted, as work was initiated in this field several years ago, the then-available data which indicated that over 60 percent of the total hydrocarbons emitted to the atmosphere from automobile exhaust came from the engine during deceleration, when there is essentially no combustion. Without waiting, as would be normal, for the development of instrumentation and test techniques and the running of sufficient tests to determine similar information, the induction system panel initiated a vigorous cooperative program to develop a deceleration device to decrease hydrocarbon emission during deceleration. After several years of work two types of devices were perfected and submitted to the Los Angeles County Air Pollution Control District for evaluation.

By this time, however, the work of the CRC panels and other automotive industry groups working on the problem indicated that only 20 to 30 percent of the total hydrocarbons emitted to the atmosphere from automobile exhaust came from the deceleration cycle, rather than the 60 percent figure which had been assumed when the device-development program was initiated. The application of a deceleration device thus appeared less promising in terms of reducing total hydrocarbon emission to the atmosphere from automobile exhausts.

The exhaust system panel has conducted basic research on several types of afterburners for oxidizing hydrocarbons in the exhaust system and currently has a vigorous program dedicated to developing a catalytic converter. Results to date have been encouraging but a large time factor is still required for such a device to be developed to the point of commercial acceptability in terms of hydrocarbon elimination efficiency, catalyst life, and both original equipment and catalyst replacement cost. Work is also progressing in the development of direct flame afterburners.

The carbon monoxide panel of the Vehicle Combustion Products Committee has developed a useful procedure for measuring carbon monoxide concentration in passenger compartments. This procedure was used by the panel on exhaust systems engineering to show the feasibility of many alternate exhaust system locations. The panel on exhaust systems engineering has also developed a performance criterion rather than a design criterion for specifying exhaust system location on automobiles.

The panel on visible smoke emission, in cooperation with Detroit officials, has developed a color movie as a training aid to enable police officers to detect a motor vehicle, bus, or truck with excessive and/or unnecessary visible exhaust smoke emission. An exhaust smoke guide was also developed, printed, and made available.

The medical panel has been considering a program to study the health aspects of automobile exhaust and in this study the members of this panel have consulted quite often with the staff of the Public Health Service. It is planned that this cooperation between the health service and the automobile industry will be continued.

The traffic survey panel conducted a full-scale survey in a large metropolitan area to determine how people drive their automobiles. The results of this study are quite substantial and have been published and made available to all interested parties.

The data analysis panel has kept the Vehicle Combustion Products Committee up to date on recent data by analyzing and comparing the data from all the industry activities concerned with automobile exhaust and air pollution.

Conclusions

As described above, the automobile industry has spent a considerable amount of time and effort defining the automobile exhaust-air pollution problem, developing instrumentation, developing devices, studying drivers and cars in the field, and otherwise amassing a tremendous amount of pertinent information. It appears that the industry is now close to having acquired sufficient technical knowledge to control some undesirable exhaust emissions. It is also felt that many private industries have been stimulated by the industry attack on this problem to initiate their own programs to develop devices for controlling exhaust emissions. With the number of companies working on the problem and the number of prototype devices now being made available for test, a commercially acceptable exhaust-system device should result.

There appear to be several things which need to be done in the future to control air pollutants in automobile exhaust:

1. Those industries presently engaged in developing exhaust-system devices should continue their work at a vigorous rate, since many problems remain to be solved in order to achieve a commercially acceptable device.
2. The automobile and petroleum industries should continue their cooperative endeavor to develop and improve analytical techniques and should continue to study exhaust gas composition. In addition, others working in this field should also continue their efforts.
3. The automobile industry should continue its study of the maintenance aspects of the automobile exhaust-air pollution problem.
4. The Public Health Service and other health agencies should continue their program on the health aspects of all air pollutants

in order to expedite the development and application of control methods.

5. The study of atmospheric reactions should be continued so that, as control methods become available, those urban areas afflicted with an air-pollution problem can determine whether or not the application of such control methods will be effective in their particular problem.

Extent to Which Available Control Techniques Have Been Utilized by Communities (1)—Los Angeles County

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During the past half century the North American Continent has seen an explosive growth in population and the birth of hundreds of large urban and metropolitan areas. As delightful, convenient, and rewarding as this pattern of development has been, it has not occurred without creating certain problems. Air pollution is one of them.

At its worst, air pollution has killed. It killed in Donora, Pa.; in London, England; in Posa Rica, Mexico; and in the Meuse Valley of Belgium. There are some informed people now who feel strongly that it may be affecting the health of the people in metropolitan areas throughout the world. In some places, air pollution has been little more than an annoyance—buildings streaked with soot and grime; clean washings dirtied by the soot fall from a passing locomotive or from a neighboring industrial plant, a bad odor from a nearby operation. In other places, air pollution has damaged vegetation, killed livestock, damaged property, produced great economic loss, and been a cause of irritation to the public.

Regardless of the character an air-pollution problem assumes, it is a responsibility of the local community to determine the action needed to ascertain the level of air quality it desires. In Los Angeles, the community experience with air pollution has been so unpleasant that the residents just do not want air pollution in any form, whether it is a bad odor, a blotch of smoke on the horizon, or a direct contributor present in other areas. A community can decide, and must decide, for itself whether it wants a contaminant-clouded air supply, whether it wants near purity in its atmosphere, or whether it wants some quality level in between these extremes. The choice should be made at an early date.

In making this choice, two factors are of particular importance: local need, and a community willingness to pay the price for clean air. Air pollution problems throughout the country are not the same. There are variations in effect, in severity, in frequency, and in the impact on the community.

The general cause of a community air-pollution problem is rather obvious—too much pollution and too little air. These two factors are neither constant in the same area nor constant between different locales. Some cities like Chicago, for example, have high wind speeds and can tolerate a higher rate of contaminant emissions into the atmosphere than Los Angeles, which is notorious for its light winds and low temperature inversions. In a sense, more caution must be exercised in southern California than in other places, simply because the supply of air is not quite so large.

Two other important considerations are the quantity and character of pollution. Obviously, some types of pollution can be thrown into the air supply of an area without creating much of a problem. Beyond a critical threshold point, however, effects will be felt and a community will have to decide whether it chooses to recognize the effects as problems and be willing to pay the price for control.

No longer can the air in an urban area be considered "free." If a community wants an air supply pure enough to meet local requirements and demands, then the community must be willing to pay a certain price. In Los Angeles, the price has been high because the control program was a pioneer effort. The price in other areas should be much lower because of that effort. Results, answers, and techniques now are available that can be of benefit to many other areas. It would be a shame to repeat the experiences in Los Angeles in every urbanized area. The mistakes and accomplishments in Los Angeles can be guidelines for other areas to follow, and the price the community pays, therefore, should be far less than it was for Los Angeles.

Any community which suffers from an air-pollution problem must inevitably turn its attention to the operations of industry. Historically, it is these operations that are most frequently associated with community air-contamination problems.

In keeping with this tradition, it was to these activities that the Los Angeles County air-pollution-control program was first directed. From 1947 to 1957 our antipollution program was exclusively an industrial pollution-control program.

It is this program that has been responsible for all of the progress realized in curbing air-pollution conditions in Los Angeles County—with the single exception of the 1957 ban on refuse burning.

It is estimated that from 1,500 to 2,000 tons of air contaminants currently are prevented from entering the Los Angeles atmosphere each day as a result of the industrial source control program. Without these controls, air-pollution conditions in this area would be infinitely worse. It is even possible that contaminant concentrations would be so high as to render the atmosphere dangerous to human health and safety.

Controls considered routine and normal on industrial equipment and operations in Los Angeles County are all but unheard of in other sections of the United States and even in other areas of California. Because of the $70 million which has been spent by industry on carefully engineered pollution-control equipment, Los Angeles County leads the Nation in control of industrial sources of air contamination.

This record has been achieved through a careful program of identifying harmful contaminants present in the Los Angeles atmosphere and determining the sources from which they are derived and, finally, through the enactment of rules prohibiting or restricting their emission from significant sources.

Today, air-pollution-control district rules and regulations affect the operation of every industry located within this county. They place prohibitions and restrictions on the emission of visible plumes, sulfur oxides, dusts and fumes, hydrocarbons, particulate matter, combustion contaminants, and nuisance-creating substances from industrial sources.

Through their enforcement, control measures have been applied to such diverse sources and operations as coffee roasters, petroleum refineries, rock crushers, and asphalt plants. From the smelting of metal to the painting of manufactured goods, industrial operations have been brought within the scope of the air-pollution-control program.

This has demanded careful inventories of potential pollution sources, determination of the conditions under which pollution emissions occur, and the development of air-pollution-control equipment or remedial practices for each source category.

Control of a source is obtained through enactment and enforcement of a rule which may state a maximum permissible pollution emission from the source, require the installation of a particular type of control on the source, or prohibit partially or entirely a certain practice, operation, or device.

To meet constitutional requirements, air-pollution-control rules and regulations must not be unreasonable, capricious, or arbitrary. Evidence must be provided by the district showing that compliance with the standards imposed by the rule or regulation is possible, and that persons therefore will not be denied their rights to engage in lawful occupations. In essence, this requirement means simply that a reasonable solution must be available before any industrial source problem can be solved through legal compulsion.

In short, our engineering and control technology must stay one pace ahead of our legally compulsory control enactments.

In staying at least one pace ahead of the problem, our control program has produced many engineering "firsts" during the 10-year history of the activity. These are described in the appendix.

Several thousand air-pollution-control devices have been installed on industrial plants in Los Angeles County. These vary widely in cost and collection efficiency. Among them are the following major types:

1. Electrical precipitators are used to separate and collect particulate matter from waste gas streams. The control device contains oppositely charged, high-voltage plates and wires. The solid materials in the gas stream are given an electrical charge by the wires, and then are attracted to the oppositely charged plates. Periodically, the particulate matter deposited on the plates are "rapped" or washed off and collected for harmless disposal.

2. Baghouses also are used for the collection of particulate matter, and function much like the household vacuum cleaner. Waste gas streams are fed to baghouses through inlet headers which allow the gas to be introduced under pressure into the bags. The house itself consists of a number of tubular bags made of glass fiber, felt, or other similar material. In passing through the bags and into the atmosphere, the gas stream is cleansed of the contaminants, which are collected in the bags. The filtered particulate matter is removed

by stopping the gas flow and shaking the bags, allowing the material to be collected in hoppers.

3. Fume burners incinerate the combustible materials contained in a waste gas stream. Devices of this sort consist of a refractory-lined shell equipped with one or more natural gas burners. Time and temperature are most important factors in the ultimate efficiency of such a device.

4. Collectors and separators of various types also are used to collect solid materials. Cyclone separators employ the principle of centrifugal force to throw the solids out of the swirling gas stream, and therefore function much like a cream separator. Settling chambers may be used to collect large solids. These function by slowing the gas stream to permit the fallout of heavy particles into the settling chamber. Another technique permits the collection of solids by passing the gas stream over cooled or heated plates which collect the solid materials.

Sonic precipitation uses high-frequency sound waves to cause the particles to collide and cling together. These larger particles then can be removed easily through settling processes.

5. Scrubbers and washers cleanse particle-laden gas streams by use of a spray which strikes the solids and washes them from the gas. Gas also may be bubbled through a liquid bath for cleansing.

6. Vapor-collection equipment is used to capture vapors generated during the storage or handling of gasoline and other petroleum products. The vapors are drawn from storage vessels through vent pipes to collection equipment such as vaporspheres. The control system may provide for compressing the collected vapors back into a liquid state, or may process them for removal by absorbers or incinerators. In some cases the vapors can be used to fire boilers, or they can be incinerated in a fume burner.

7. Absorbers involve a process in which one material is employed to take up and retain another. They are used to selectively remove a gaseous or liquid material from another gas or liquid. Usually, the process is performed in cylindrical towers which are packed with an absorbing material. Representing a very large absorbing area, the packing serves to spread the liquid or gases and thus hastens and makes more efficient the absorption process.

8. Adsorbers also are employed in the control program. They involve a physical process in which the molecules of either a gas or a liquid are captured by a solid material. Usually, the capturing solid is activated carbon which has a large surface area in the form of very small tubes, called capillaries. The molecules to be removed are passed over the activated carbon where they enter, and are captured by, the capillaries. The carbon can be regenerated by steam which drives off the adsorbed material in the form of a vapor which is then condensed along with the steam.

Each type of device possesses advantages and limitations that must be considered carefully. Each source poses different problems in terms of the volume, temperature, and characteristics of the waste emitted from it. In effect, a solution must be tailormade to the source. The degree of control which a community requires will dictate, in the main, which type control will be utilized and the cost of the control system.

The district's permit system assures that consideration is given to each potential industrial pollution source. Before any equipment capable of causing or controlling a pollution emission may be constructed or operated, permits are required from the air pollution control district. District engineers, versed in air-pollution problems of specific industries, review plans, specifications, operations, and emission analyses for the equipment in question before issuance of an "authority to construct" or a "permit to operate" is authorized.

A comprehensive industrial plant inspection program has assured that this careful technical review has been given the industrial sources operating in Los Angeles County.

To illustrate the results that have been obtained from the district's industrial pollution-control program, a review of several potentially significant industrial activities is in order. Among the most important activities in the Los Angeles area are petroleum refineries, sulfur recovery and sulfuric acid plants, metallurgical plants, mineral processing establishments, steam powerplants, organic solvent installations, and processes involving the combustion of refuse.

Petroleum Refineries

During 1949 and 1950, potential air-pollution sources in petroleum refineries were inventoried by district engineers and classified into 19 general categories. Control measures then were recommended for each type source.

Emissions of smoke from emergency flares, boilers, and heaters were attacked through direct field enforcement activity. Solutions to more complex problems were attained through careful engineering studies and through the enactment of specific control rules.

Although the refineries had already partially curbed the emission of sulfur oxides from their operations, no definite overall program had been initiated for sources of hydrocarbons. These sources were deemed of most importance by the district and have been the subject of several specific control measures.

Storage tanks, oil-water separators, emergency flares, pumps, and large-volume loading racks now have been controlled through the installation of costly collection and control equipment.

Vapor losses from hydrocarbon storage tanks have been curbed through enforcement of rule 56, enacted in 1953. The first control measure of its type to be enacted anywhere in the world, the rule specifies that all tanks of greater than 40,000-gallon capacity must be controlled when they are used for the storage of a petroleum distillate having a vapor pressure of 1.5 pounds per square inch absolute or greater. This one rule has resulted in a reduction of hydrocarbon vapor losses of approximately 250 tons per day. It affects more than 1,000 tanks and 16 million barrels of storage capacity. The degree of compliance is 100 percent.

Several years ago, great clouds of black smoke were released from emergency flares whenever they were used to burn the excess gas surges created by upset or abnormal refinery operations. Some of the first smokeless emergency flares in the Nation were designed, proved by experimentation, and built in Los Angeles County. After their development, they were adopted and installed throughout the refining industry in Los Angeles County. Smoke emissions from this particular source have not just been reduced; they have been eliminated.

Attempts to control oil-effluent water separators began in 1953 and led to the enactment of rule 59 in 1955. Requiring the control of separators, this rule has been effective in preventing the emission of malodors and approximately 100 tons per day of hydrocarbons. Compliance with the rule is 100 percent and, so far as is known, Los Angeles County is the only area of the United States in which controls for separators are required and used.

Rule 61, which was adopted in 1956, requires that hydrocarbon vapors from large-volume loading of gasoline into tank trucks be collected and disposed of in an approved system. Approximately 30 tons per day of hydrocarbons now are prevented from being discharged into the atmosphere during loading operations. There is no other area where vapor losses from gasoline loading are prevented in this way and, in fact, controls did not exist prior to their development in Los Angeles.

Catalytic cracking units in most other refining areas can be identified from afar by their emission of catalyst dust or a persistent plume. Electrical precipitators and centrifugal collectors are used for catalyst dust collection and such losses are no longer a problem. On fluid catalytic cracking units, carbon monoxide waste-heat boilers are being installed. There are six fluid catalytic cracking units in the county. Of the four largest, one is already equipped with a carbon monoxide waste-heat boiler and two others are being so equipped.

In recent years, all vacuum jets (once responsible for emissions of 17 tons per day of hydrocarbons) have been controlled by condensation followed by the burning of noncondensable vapors. Light hydrocarbon vapor losses from centrifugal pumps with packed gland seals have been reduced from 35 tons per day to 5 tons per day. This has been accomplished through their replacement or conversion to mechanical seal pumps. Accumulator vents and relief valves now are vented to recovery systems or other approved disposal systems.

Other problem emissions controlled include the oxidation of sour water or the conversion of the ammonia contaminant to ammonium sulfate and the hydrogen sulfide to sulfur.

The only reversal to the year-by-year trend of lowered pollution levels from refineries is the vapor loss from storage tanks, which has risen due to increased usage of floating roof tanks. To partially counteract this, an amendment to rule 56 was adopted this year which limits the use of floating roof tanks for petroleum distillate storage to those distillates of lower volatilities. Concurrently, close attention is being paid to new developments in floating roof seals and covers that will increase their efficiencies.

No recital of control accomplishments for oil refineries is complete without mention of another important air contaminant—sulfur dioxide. Amine absorption systems have been installed to remove hydrogen sulfide from refinery byproduct gas and to convert it to sulfur or sulfuric acid. In this way, approximately 600 tons of sulfur dioxide are prevented from contaminating our atmosphere each day.

Sulfur Recovery and Sulfuric Acid Plants

The control of sulfur dioxide was one of the first major programs undertaken by the air-pollution-control district after its formation in 1947. This action was inspired by the experience of other cities or areas which had found emissions of sulfur dioxide undesirable or even detrimental. One of the most successful phases of this effort involved the control of sulfur dioxide from sulfuric acid plants, all of which now are operating in compliance with rule 53a. This rule limits the concentration of sulfur dioxide in the effluent gases to a maximum concentration of 0.2 percent by volume.

Not all of the hydrogen sulfide from refineries was being utilized in the sulfuric acid plants. Much of it was being burned. The next breakthrough in the sulfur dioxide program, therefore, came with the development of the sulfur recovery plant, and with the expansion of hydrogen sulfide extraction facilities in the refineries. The sulfur recovery plant—which did not exist prior to the formation of the air-pollution-control district—converts the hydrogen sulfide from refineries to elemental sulfur.

In 1948, it was estimated that approximately 400 tons per day of sulfur dioxide were being emitted to the atmosphere from all Los Angeles refineries, which at that time had a total crude throughput of 450,000 barrels per day. Another 125 tons per day of sulfur dioxide were being prevented from entering the atmosphere by the existing sulfuric acid plants processing hydrogen sulfide.

In 1949, the first sulfur recovery plant was constructed to produce elemental sulfur from the hydrogen sulfide extracted by four refineries. In 1950, two more refineries began recovering their hydrogen sulfide and trucking it to a sulfuric acid plant. Because of costs, by 1953 both had installed their own sulfur recovery plants.

Today, Los Angeles is the only major petroleum refining center that has accomplished substantial control over sulfur oxide emissions. With an average crude oil throughput of about 700,000 barrels per day, more than 500 tons per day of sulfur dioxide are being prevented from entering the atmosphere by the processing of recovered refinery hydrogen sulfide.

Mineral Processing

Many mineral processes throughout industry contribute to the overall air-pollution problem. Dusts are released by such processes as crushing, grinding, milling, conveying, bagging, mixing, lending, etc. Fumes are released where high temperatures are involved in the process.

The common mineral processes in Los Angeles County include the asphaltic concrete batching plants, concrete batching plants, glass container manufacturing plants, perlite, vermiculite, and other insulation plants. There are also many other plants producing specialized products involving mineral processes.

Asphaltic concrete batching plants have been controlled by centrifugal-type scrubbers. The 48 plants in the county have a loss to the atmosphere of less than 3 tons per day of aerosols. Prior to the installation of well-designed air-pollution-control equipment, these losses were more than 25 tons per day.

There are a total of 35 large glass furnaces in the county with a loss of 1½ tons per day. Small furnaces have been controlled by the use of baghouses while larger furnaces have been equipped with scrubbers utilizing impingement and entrainment separation principles. The scrubber operates at discouragingly low collection efficiencies since particle sizes of the fume fall below 1 micron. Baghouses have not yet been tried on the larger furnaces because of the extremely corrosive characteristics of the effluent. However, developmental work is continuing and the use of baghouses may be the ultimate answer to this problem.

Perlite, vermiculite, rock wool, and other insulation processes are well controlled from an air-pollution standpoint. Control of the basic furnaces is achieved by the use of baghouses. In rock-wool processes, other controls are needed, such as afterburners on cooling ovens and filters to collect generated lint.

There are many other miscellaneous mixing, batching, blending, conveying, size reduction, and classifying mineral processing systems which have not been mentioned. Many of these are unique in design and cannot be classified into separate types of equipment worthy of individual discussion. These processes are being controlled and, if not controlled, would emit many tons of aerosols into the atmosphere daily. Examples of such systems include rock and gravel crushing and classification; mica grinding and classification; sand drying; roofing granules plants; silica abrasive classification; cement handling; gypsum processes; borax processes; limestone processes; asbestos processes; diatomaceous earth processes; manufacturing of building brick, stoneware, pottery, and other ceramics; and many others.

Metallurgical Operations

A great variety of secondary smelting and associated operations are conducted in Los Angeles County involving ferrous metals, aluminum, magnesium, lead, zinc, copper, brass, and bronze, and their alloys. No primary smelting or ore-reduction facilities are located in Los Angeles County. To conduct these operations, cupola furnaces, reverberatory furnaces, electric furnaces, open-hearth furnaces, and many other types of furnaces and ovens are used. Although the emissions of dusts and fumes from this equipment are a problem common to each type of furnace and oven, the problems of collection differ, due to temperatures, equipment layout, and variations in the quantities and sizes of particle emissions.

In 1948, about 80 tons per day of dusts and fumes were estimated as being discharged to the atmosphere from these sources. With the advent of the air-pollution-control program and the necessity to comply with the rules and regulations, some members of the industry modified their operations. Thus, for example, some gray-iron production was transferred to reverberatory furnaces which could meet more easily the standards of the district.

Other members of the industry combined forces with air-pollution-control equipment manufacturers and designers and, in cooperation with air-pollution-control district engineers, established a control equipment development program. From this program resulted the development and use of the first effective high-temperature gas filtration equipment for the collection of emissions from gray-iron cupolas. The equipment, called a baghouse, also has found extensive application in controlling the emissions from electric steel, brass, aluminum, and lead furnaces. Concurrently, with the development of the baghouse, several metallurgical equipment operators installed electrical precipitators to control the dusts and fumes emitted from gray-iron cupolas, open-hearth steel furnaces, and electric steel furnaces.

All equipment emitting dusts and fumes now are equipped with control devices, which are almost exclusively baghouses or electrical precipitators.

Other metallurgical operations, besides the ferrous metal furnaces and large nonferrous metal furnaces, also have been controlled or are being studied for control. For example, foundry sand-handling systems are equipped with dust collection apparatus, and some smaller furnaces utilize slag covers over the molten metal to reduce the emissions. Another example is the continuing experimentation to develop controls more adequate than scrubbers for zinc galvanizing operations. Recent work indicates that it may be possible to adapt baghouses satisfactorily to collect the fumes from zinc galvanizing.

The air-pollution-control program has resulted in a reduction of about 90 percent of the dusts and fumes generated by metallurgical operations. Present losses are estimated at only 6 tons per day. This reduction from 80 tons per day in 1948 has been accomplished despite a large expansion of industry between 1948 and 1958.

Combustion of Waste

One problem common to all industrial and commercial establishments is that of refuse disposal. When the district was created, one of the first problems tackled was that associated with burning of industrial, commercial, and residential waste products.

The program pursued by the district has involved the adoption of prohibitions on some types of refuse burning and the development of highly effective incinerator units which can be operated without creating air-pollution problems.

Through court action and the adoption of specific prohibitory rules, all open burning dumps, open fires, and refuse burning in single-chamber incinerators have been halted in Los Angeles County.

Strict enforcement of the district's rule 50 brought an end to open burning at dumps in 1950 and led to conversion of these facilities to cut-and-cover-type operations. Beginning in 1950 also, engineering design parameters for industrial and commercial incinerator units were critically reviewed and improved. Engineering studies have continued, resulting in substantial improvements in incinerator design.

In 1953, the first approved modifications to flue-fed single-chamber apartment-house incinerators were installed. These consisted of the addition of afterburners to further combust the effluent gases. Subsequently, a number of alternate types of control devices were developed for this equipment. These involved chiefly, the conversion of the original equipment to an efficient multiple-chamber incinerator.

The major steps, however, in controlling the emissions from the burning of combustible refuse came with the adoption of rules 57, 58, and 58.1. Rule 57 banned open burning, effective July 1, 1955. Exceptions provided were for agricultural operations, the prevention of fire hazards, and the training of firefighters. Rule 58.1 banned the use of single-chamber incinerators for commercial and industrial use, effective July 1, 1957. Rule 58 completed this program by banning the use of all single-chamber incinerators after September 30, 1957. In effect, all burning of combustible rubbish was banned except when conducted in approved multiple-chamber incinerators or equipment equally effective. The major result of these measures was to eliminate most burning of combustible refuse in Los Angeles County in favor of disposal in sanitary land-fill sites.

Those operations which require the burning of combustible waste products now can be conducted only through use of multiple-chamber incinerators. District emission standards applicable to this equipment were tightened recently so as to reduce allowable concentrations of combustion contaminants from 0.4 to 0.3 grain per standard cubic foot of gas at 12 percent CO_2. The use of multiple-chamber incinerators which meet this new standard results in a decrease of approximately 90 percent in the emission of combustion contaminants as compared with the operation of single-chamber incinerators.

The combined effect of this program to control the pollution products of refuse burning has been to prevent the entry into the atmosphere of approximately 500 tons per day of smoke, fly ash, and organic and inorganic gases.

Remaining Industrial Source Problems

Although tremendous inroads have been made into the problem of industrial air pollution, the job has not yet been completed. Two operations now are under attention, and steps have been taken to bring about their control. These include the combustion of fuel oil by powerplants, refineries, and other large industrial sources, and the manufacture, processing, and use of organic solvents.

With the fulfillment of activities directed toward these two broad industrial pollution problems, the major portion of our industrial control effort will have been brought to the point of completion.

Steam Powerplants

None of the 71 boilers now operating in 12 steam powerplants in Los Angeles County are equipped with air-pollution-control devices other than dust collectors used during periods of soot-blowing.

These units discharge visible smoke emissions when fired with heavy residual fuel oil and emit substantial quantities of sulfur oxides, particulate matter, and oxides of nitrogen.

The Joint Research Council on Power Plant Air Pollution Control was formed in 1956 for the express purpose of eliminating air contaminants from powerplant flue gases. Since then a great deal of money has been spent by participating powerplant operators, both on the study of plume formation and on means of removing pollutants.

An important result attributable to this research is the installation now being made by Southern California Edison Co. of a $1 million electrical precipitator at their El Segundo facility to remove more than 90 percent of the particulate matter from exhaust gases.

Strong efforts have also been made to secure additional natural gas supplies so that fuel oil burning can either be eliminated or restricted to periods when weather conditions are not conducive to smog formation. This approach toward reducing air pollution from powerplants has been carried to the point of preparing legislation and introducing it at a public hearing on October 22 of this year. During the period encompassed by the proposed rule, legislation would prevent the daily emission of approximately 400 tons of contaminants from the burning of residual fuel oil.

Organic Solvent Consumption

In the industrial, commercial, and domestic activities carried on in Los Angeles County many different solvents are used which are eventually vaporized into the atmosphere. Alcohols, ethers, paint thinners, and lacquer thinners are included in the definition of organic solvents. These organic solvent vapors react in the Los Angeles atmosphere to produce smog in the same manner as gasoline vapors. The district presently is measuring the reactivities of individual solvents and rating them in respect to their capabilities for smog formation. The most recent estimates indicate that about 400 tons per day of these solvents are discharged into the atmosphere.

Control of organic solvents has presented three basic problems typical of air-pollution control—control development, chemical identification, and legal regulation. Determination of suitability of known control measures, and development of adequate control devices where none formerly existed, are the most readily recognized problems. To evaluate control measures implies the availability of accurate and readily usable methods of air-contaminant measurement. Answers to these two problems then permit the establishment of rules limiting the losses from specific sources. As there are at present no rules limiting these sources, solutions to these three phases are being developed concurrently.

Equipment for control of gases with high concentrations of hydrocarbon solvents is now commercially available. Catalytic afterburners of two general types have been installed on several sources, particularly lithograph ovens. These have reduced hydrocarbon emissions by more than 16,000 pounds per day. Direct-fired afterburners have been installed on paint-baking ovens, varnish thinning tanks, and other equipment where high solvent concentrations may be expected.

Possibly the most significant innovation of recent months has been the development of a packaged activated carbon adsorption unit adaptable to certain small operations using chlorinated hydrocarbons. Installations in only 15 drycleaning establishments already have reduced solvent emissions by about 1,000 pounds per day. An important feature of the carbon unit is that it is reported to be economically attractive to the user. In effect, it permits cleaning with an efficient but expensive solvent at a cost comparable to that of cheaper and less effective solvents.

Solvent losses, where the concentration of hydrocarbons is low, pose a more difficult or expensive control problem. The spraying of surface coatings is the largest contributor to losses of this type. Since no entirely suitable method of control for paint spraying is available, the district itself has undertaken the necessary engineering development studies. Under a demonstration grant from the U.S. Public Health Service, the air-pollution-control district has designed and constructed equipment for developmental studies under a variety of desired conditions. This study now is in progress and is pointed toward the development of an efficient, economical control system for paint spray booths and ovens.

Dilute solvent vapors that do not contain entrained particulates may be efficiently controlled by activated carbon adsorption. A large regenerative adsorption unit recently has been installed as a voluntary air-pollution-control measure on a rotogravure printing press. This unit has a design capacity for the removal of 1,800 pounds per day of ketones, esters, and alcohols. Test data indicate a removal efficiency of about 99 percent, but sufficient operating information has not yet been acquired to determine savings accurately.

There are installations in Los Angeles County emitting more than 10,000 pounds per day of similar solvents which could readily be adapted to adsorption recovery. The companies have made preliminary evaluations and found recovery units to be economically feasible but have not installed the units because of the high initial capital costs.

The most recent solvent survey data show about 100,000 pounds per day of chlorinated hydrocarbons to be emitted from metal degreasing operations. Many of these units contain control devices of some type, which are not in themselves adequate from an air-pollution-control standpoint. There is presently an extensive investigation by a commercial organization toward the adaptation of activated carbon adsorption techniques, such as the previously noted package units, to the control of small- and medium-sized degreasers. Chlorinated hydrocarbons are expensive, and prevention of losses may mean real savings to the operators. It is anticipated that the first control device of this nature will be installed in Los Angeles in early 1959.

Control of many sources of solvent vapors is presently feasible, as shown by the previous examples. Actual installation of control devices, however, has in general occurred only where the installation resulted in direct financial gain for the operator or where violations of existing regulations governing opacity were found. The absence of a specific rule limiting solvent emissions has prevented the assurance that proposed control devices could meet the requirements of any future prohibition.

Analytical methods must be found that are adaptable to field measurements, that will measure quantitatively the wide variety of organic chemicals encountered, and that will provide reproducible results. The air-pollution-control district is at present evaluating three separate methods, and a satisfactory solution is believed to be imminent.

Enactment of a rule regulating all solvent emissions must await the establishment of reasonable emission standards and the development of suitable methods for measuring vented contaminants. Initial drafts of possible rules presently are being evaluated by the air-pollution control district. It may be possible, however, to enact legislation effectively covering some of these sources before all answers to the overall problem become apparent.

Total Air Pollution Summary

The diversified control program pursued by the air-pollution-control district for all known sources of air contaminants has resulted in almost complete control of some sources and a gratifying degree of control for others. In the case of a few sources, control devices are not available or the evidence to substantiate the need for controls and legislation is not yet at hand. Through engineering development and evaluation studies, constant attempts are being made to find new and better control methods and to apply known controls to new air pollution problems.

The severity of air-pollution conditions has compelled the Los Angeles County Air Pollution Control District to promulgate the most stringent rules possible for controlling sources of air contaminants, as soon as technically sound and economically feasible control methods have become known. A rule or regulation cannot be arbitrary, unreasonable, capricious, or confiscatory. Without proper technical substantiation, legislation will not withstand the test of time. To gain the information upon which a rule must be based, it is necessary to determine the size of the problem, the extent to which control is essential, and the sources of the contaminants, so that a breaking-off point can be fixed. It is obvious that a rule cannot require 100 percent control. Where the breaking-off point is established depends on the information gathered during the investigation.

One of the most important types of data that any control agency must obtain, and maintain, is that concerning the quantities and types of air contaminants emitted from all types of sources in the area under consideration. For the past 8 years, the district has maintained a total pollution survey which includes statistics, by category of sources showing the emissions of all types of contaminants into the atmosphere daily. This continuous survey is made for several reasons: first, it is invaluable in serving as a method for evaluating the progres of the total control effort; second, it is useful as a comparison with the atmospheric concentrations obtained through the air monitoring program; third, it indicates clearly those sources requiring control attention.

Table I shows the total daily emissions from all types of sources located in Los Angeles County.

The larger the area under control, the more difficult is the task of obtaining original data and of maintaining the statistics on a current basis. Experience has shown, however, that regardless of how large or small the air-pollution-control program, it is essential that some type of statistical analysis be conducted on a continuous basis to determine the problem and the progress being made to solve that problem.

Table I.—***Summary of air contaminant emissions to the Los Angeles atmosphere, July 1958***

[In tons per day]

Source	Organic gases			Aerosols	Inorganic gases			
	Hydrocarbons	Aldehydes and ketones	Other		Nitrogen oxides	Sulfur dioxide	Carbon monoxide	Other
Transportation:								
Automobiles [1]	750	9	11	23	320	35	3,200	(2)
Trucks and buses:								
Gasoline	250	3	4	9	110	13	1,000	(2)
Diesel	(2)	(2)	1	2	3	1	2	(2)
Petroleum:								
Refining	55	2	(2)	5	5	50	1,200	4
Storage [3]	80	0	0	0	0	0	0	0
Marketing	55	0	0	0	0	0	0	0
Production	60	(2)	0	0	(4)	(2)	(4)	0
Organic solvent uses:								
Surface coating	90	21	20	2	0	0	0	0
Degreasing	20	1	45	0	0	0	0	0
Dry cleaning	20	0	8	(2)	0	0	0	0
Other	50	20	25	1	0	0	0	0
Combustion of fuels:								
Liquid	1	1	4	30	160	350	(2)	(2)
Gaseous	5	1	3	8	100	50	1	(2)
Incineration:								
Industrial	(2)	(2)	1	1	(2)	(2)	1	(2)
Commercial	(2)	0	(2)	(2)	0	0	(2)	(2)
Municipal	(2)	0	(2)	(2)	(2)	0	(2)	(2)
Other	(2)	(2)	(2)	(2)	0	0	2	0
Chemical:								
Sulfur and sulfuric acid	0	0	0	0	0	45	0	0
Other	16	8	16	3	(4)	1	(4)	1
Metals	0	0	0	6	0	(2)	180	0
Minerals	2	0	0	6	0	(2)	0	0
Miscellaneous	(2)	(2)	(2)	2	(2)	(2)	(4)	(4)
Total [5]	1,450	65	140	100	700	550	5,600	5

[1] Includes trucks under 4,000 pounds unladen weight.
[2] Less than 0.5 ton per day.
[3] Includes storage of petroleum products at refining and marketing installations.
[4] Unknown.
[5] Totals have been rounded out.

APPENDIX.—*Los Angeles County "Firsts" in Air Pollution Control*

Date placed in operation	Equipment	Cost	Remarks
January 1948	Exhaust system with baghouse serving brass-melting crucible furnaces.	$4,000	First brass furnaces of this type to be controlled.
August 1949	Exhaust system and baghouse serving an electric steel-melting furnace.	2, 500	First electric steel furnace ever to be controlled with a baghouse.
February 1950	Afterburner serving a coffee roaster	1, 800	First coffee roaster ever equipped with afterburner.
June 1950	Afterburner for a varnish-cooking kettle	2, 000	First direct-fired afterburner and the first really satisfactory control device on a varnish kettle.
August 1950	Exhaust system and electric precipitator with waste-heat boiler serving an open-hearth steel-melting furnace.	150, 000	First open-hearth furnace to have satisfactory air-pollution-control equipment.
November 1950	Electric precipitator serving an aluminum dross recovery plant.	30, 000	First dross recovery plant ever controlled by a precipitator.
December 1950	Chemical plant to recover elemental sulfur from refinery waste hydrogen sulfide.	1, 150, 000	First chemical plant in Los Angeles County to recover waste hydrogen sulfide gas and convert to elemental sulfur.
January 1951	Exhaust system, quencher, and baghouse serving 2 iron-melting cupola furnaces.	15, 000	First iron cupola ever to be satisfactorily controlled.
February 1951	Baghouse serving a galvanizing kettle	1, 000	First baghouse to serve a galvanizing installation.
May 1951	Water spray cooler and baghouse filter serving an asphalt roofing paper saturator.	25, 000	First baghouse ever to be used to control oil mists from an asphalt roofing paper saturator.
January 1952	Electric precipitator serving an iron-melting cupola.	40, 000	First electric precipitator ever used to control a gray-iron melting cupola furnace.
Do	Exhaust system with electric precipitator serving two 75-ton and one 50-ton electric steel melting furnaces.	650, 000	First satisfactory installation ever to control large electric steel-melting furnaces.
February 1952	Pease-Anthony Venturi-Cyclone scrubber	25, 000	First ceramic frit smelter to be controlled satisfactorily.

APPENDIX.—*Los Angeles County "Firsts" in Air Pollution Control*—Continued

Date placed in operation	Equipment	Cost	Remarks
April 1952	Exhaust system with afterburner and baghouse serving aluminum sweat furnace and a rotary aluminum chip drier.	$6,000	First really satisfactory installation ever to control such nonferrous operations.
February 1953	Water scrubber serving galvanizing kettles	12,000	First control device capable of controlling odors and gases from a galvanizing operation.
Do	Boiler firebox and crude oil absorber serving refinery waste-water system.	340,000	First controls for a refinery waste-water system in which separator is covered and collected gases are absorbed and incinerated.
June 1953	Water scrubber coupled with electric precipitator for controlling fumes from fluxing of aluminum in a reverberatory furnace.	45,000	First such control system ever installed for the combined problem of fluoride and chloride fluxing fumes.
July 1953	Electrostatic precipitator serving an asphalt roofing paper saturator.	40,000	First 2-stage electrostatic precipitator ever installed to control a roofing paper saturator.
November 1953	Water scrubber for control of fumes from airblown asphalt manufacture.	45,000	First installation ever to use a sea-water scrubber.
Do	Sour water oxidizer to convert odorous sulfides into water-soluble thiosulfates.	30,000	First installation for disposal of sulfides in effluent water as contrasted to standard method of burning to sulfur dioxide.
December 1954	Absorber unit employing gasoline as the absorbing medium for recovery of vapors collected from bulk loading of tank trucks.	40,000	First installation of its type ever to be designed and installed.
January 1956	Vapor-collection system for gasoline loading rack at refinery.	30,000	First vapor-collection system to collect escaping hydrocarbon vapors released in bulk loading of gasoline into tanker trucks at loading racks in refineries.
April 1956	Flue gas heater serving a fluid catalytic cracking unit.	80,000	First installation on a fluid catalytic cracking unit to prevent formation of sulfur trioxide and resulting plume.

Do	Direct-flame afterburner on a paint bake oven	5, 000	First paint bake oven equipped with a direct-flame afterburner to control emissions.
Do	Direct-flame afterburner serving meat smokehouse	4, 000	First direct-flame afterburner ever installed on a meat smokehouse.
October 1956	Baghouse with radiant cooling ducts on glass furnace.	8, 500	First installation of control system on glass furnace.
November 1956	Scrubber coupled with an electrostatic precipitator serving meat smokehouses.	10, 000	First such control device ever installed to control smoke from smokehouses.
March 1957	System for control of discharge from coker unit blowdown, consisting of water scrubber, condensers, and final discharge to refinery flare.	385, 000	First system for control of hydrocarbons from coker unit blowdown.
October 1957	Exhaust system with baghouse serving 4 stereotype metal melting pots.	9, 000	First such controls ever installed at a printing establishment to control metal-melting operations.
January 1958	Direct-fired afterburner serving plastic-curing oven	2, 800	First afterburner ever installed to control the discharge from a plastisol curing oven.
February 1958	Activated carbon adsorber installed to control solvent losses from drycleaning plant.	4, 000	First such installation for this type cleaning plant.
March 1958	Direct-fired afterburner on a large paint-baking oven.	16, 000	First installation of its kind on an automobile paint bake oven.
Do	Activated carbon vapor adsorber on a 5-color rotogravure printing press.	48, 000	First regenerative activated carbon adsorber unit serving rotogravure press and which was installed strictly for air-pollution control purposes.
Do	Activated carbon adsorber serving 47 paint-mixing tanks.	10, 000	First such installation made at an automobile manufacturing plant for the purpose of controlling solvents.
April 1958	Catalytic afterburner on paint bake oven in an automobile assembly plant.	70, 000	First catalytic afterburner installed to control paint-baking oven in an automobile assembly plant.
To be completed in 1959.	Electric precipitator serving a 1,254,000-pound-per-hour oil-burning steam generator.	1, 000, 000	First time any oil-burning steam generator has ever been equipped with an air-pollution-control device other than controls for soot blowing.

Extent to Which Available Control Techniques Have Been Utilized by Communities (2)—Philadelphia

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In developing this portion of this panel discussion, I would like to review a few administrative considerations that we have found important in Philadelphia to achieve wider use of available control techniques. There is much known about control that is not used and one of the primary jobs of the local official agency is to secure maximum use of available knowledge. However, we have encountered a number of situations where the community social and economic aspects of air-pollution control presented problems as difficult and sometimes more difficult to solve than the technical questions.

Specific sources which create neighborhood nuisance-type air-pollution problems are usually amenable to correction by using practical established methods of control. General areawide air-pollution problems resulting from many contributing sources are not so easily defined and reduced. In part, this is due to an absence of precise limits of acceptability for air pollution. We believe that agencies such as the U.S. Public Health Service should exercise leadership in the research necessary to establish maximum allowable concentrations of air contaminants in outdoor air.

Solution of these general area problems will not be easy, since a change in the basic habits and organization of communities may be required. Examples of where change may be indicated are the transportation modes of urban areas and the quality of fuels for residential and industrial use. Reduction of sulfur content of fuels consumed would materially reduce the sulfur dioxide content of a city's air. Federal assistance in developing the solution to problems of this magnitude is indicated.

To avoid control for control's sake, Philadelphia has outlined the objectives of its air-pollution control program. These are: (1) to protect the public health; and (2) to foster the maximum economic and social development of the community. We are mindful that industry is necessary to the economic health of our city, and at the same time we realize that uncontrolled air pollution causes neighborhood deterioration resulting in decadence. We try to steer a course that will produce both social and industrial vitality.

Ways by which we attempt to assure greater and more efficient use of available knowledge are: (1) long-range planning based on air sampling coordinated with meteorological studies; and (2) identification and inventory of sources of air pollution; and (3) community participation in control efforts through advisory committees.

In areas where there is grossly excessive air pollution, almost any individual can observe the necessity for corrective action. However, we find under other conditions that it is impossible to definitely assess the extent to which our air resource has been spoiled without air sampling coordinated with meteorological studies. Both areawide and localized problem situations deserve attention in such investigations.

How can we plan for future community growth without knowing how much air is available, any more than we can without knowing how much water is available? We already know that air is not an inexhaustible resource. In planning the future development of a community, we must realize that where 80 percent removal of pollutants before discharge may be acceptable now, a simple increase in volume of production could require 90 to 99 percent treatment to maintain the quality of air at present levels. It is obvious that a powerplant consuming 60 tons of coal per hour could cause more pollution and should require greater efficiency of control than a 60-tons-per-day operation. While extremely high efficiencies cost more proportionately, we should recognize that an increase of just 2 percent, from 96 to 98 percent, will reduce the amount of pollution discharged 50 percent.

We have just made modest beginnings of such explorations in Philadelphia. Some smaller communities may not have personnel or resources available for these investigations, but they can sometimes contract with private consultants or institutions for such service, and in some instances this service may be available from the State air-pollution control agency. There have been instances where industry has financed such fact-finding surveys. Where such investigations may serve to establish patterns useful elsewhere, Federal assistance may be indicated.

While Philadelphia has been fortunate in that its local topography does not encourage the accumulation of air pollutants to the same degree as other more publicized areas, we do have inversion periods when the effects of air pollution are accentuated. Our Weather Bureau office is correlating meteorological phenomena with our air-sampling data to develop a forecasting of such events and their duration. We have already made some use of such alerts to advise certain industries so that normal operations could be curtailed or adjusted until the episode passed. An industrial concern recently proposed to operate needed air-pollution control equipment only during periods of adverse weather. This was a system where catalytic oxidation provided about 70 percent removal of odorous and irritating organic substances before discharge to a high stack. Fuel input alone cost $75,000 per year. While we did not have sufficient data to warrant approval, such ideas have merit. More experimentation on the scheduling of operations in synchronization with meteorological conditions as an adjunct to control is indicated in the less congested areas of the country. Assessment of air-sampling data through comparison with other cities is complicated by the absence of standard methods for outdoor air analysis and standards for acceptability. Federal assistance in these experiments and in the development of standards appears justified.

Of equal importance to air sampling, we feel that an inventory of the sources of air pollution is essential to planning a sound program to control and prevent excessive air pollution. With the assistance and cooperation of industry, we have undertaken a number of industrywide surveys. In cooperation with industries and official agencies in the States of Pennsylvania and New Jersey, such industrywide source surveys have been extended to include plants in the Delaware Valley outside the limits of Philadelphia. These surveys have been accomplished without the enactment of special legislation, the establishment of special authorities, or special grants or appropriations. We simply agreed informally to cooperate and used existing personnel resources. We have found information from the various source surveys invaluable in the formation of an overall perspective of the problems of the particular industry and the establishment of priorities for improvements. We also ascertain the extent to which the more progressive concerns find it practical to control emissions. While we are not striving for control for control's sake, the standard of acceptability, until more precise standards are established, may be the removal of identified undesirable air pollutants to the extent that is practical.

The number of personnel available to the air-pollution control activity in Philadelphia is modest when compared with the need. Actually, we have 23 engineers, inspectors, and others assigned to air-pollution control. Since we are subject to the normal complaints and other demands for day-to-day service, it was very difficult to separate two engineers from other routine activities to perform these surveys. However, when the problem was recognized, the necessity of this self-discipline became evident. Even the community with only one engineer will find it beneficial in the long run to budget a portion of his time to industrywide source surveys.

Community participation is a cornerstone of the Philadelphia program to control air pollution. Through the extensive use of advisory committees, opportunity is provided for dedicated citizens and interested industrialists, scientists, and others to help improve conditions in their own community. Actually the citizens of the community determine the aims and objectives of any air-pollution control program and the standards for evaluation, for only through citizen understanding will activities be supported and financed. Appropriations for municipal incinerators and higher costs of consumer products when necessary are borne by the people. These committees give us an insight to the people's views. Such groups in their meetings, also, exchange information and experiences to help each other and the city achieve better air-pollution control. These valuable human resources made available to the department and the community through this means could not be purchased.

The department, in turn, attempts where possible to assume the role of consultant and helper to those who have air-pollution problems. Our 10 inspectors are supplied with cars equipped with 2-way radios and field test equipment. Twenty-four hours a day and 7 days a week these men can proceed rapidly to any source of air-pollution emission. These men are primarily trained in combustion control. They attempt to determine the cause of the difficulty and to assist through instruction in correction and prevention of repetition. More complex problems are referred for engineering investigation which may involve our engineering laboratory. It is important to stay with these individual problems until solved even though a man may be so engaged for several weeks. For small plants it may be necessary to help design the necessary controls.

Even enforcement is used as an educational opportunity. Informal office hearings are usually held before prosecution is initiated, to insure that the issues are understood and to attempt a final resolution before court action. While we try to understand and assist in the solution of the problems of individual offenders, we are mindful that as public servants we must serve the best interest of all the citizens of our city.

The correction of current air-pollution problems is difficult and time-consuming under any condition. The most productive effort is that applied to prevention. Our most effective procedure for prevention is the review of plans for proposed new installations and reconstructions. The department can from its experience point out pitfalls to be avoided. While not assuming the design function, the official agency should indicate types of control which will be effective.

Plan review should be coordinated with the activities of other local agencies. Zoning of land use is especially important. Location of such operations as small laundries in primarily residential areas cause problems to nearby neighbors from soot blowing which thus far cannot be sufficiently controlled. New housing developments have been constructed adjacent to coke manufacturing, rendering plants, and oil refineries, since any use above least restricted was permitted. Enough control to eliminate the resulting "across-the-fence" problems in these instances may be prohibitive in cost. Not only do residential areas need protection from encroachment of nuisance-producing industrial operations but also the industrial activities need similar protection from the encroachment of residences.

In concluding, you may rightly assume that while much progress has been made in Philadelphia to control air pollution a very great deal of work remains. Rather than recite a list of our specific problems, however, it might be more useful to consider the air-pollution problems reported in a 1956 survey.[1] (See tables I and II.)

Smoke and other products of combustion were the major air-pollution problems most frequently cited by the communities reporting. Yet, combustion processes have been well studied and control methods are known. Odors and gases were also noted as major problems by a substantial number of respondents.

Open burning of refuse, scrap, etc., was the most frequently reported major source of air pollution. This is deplorable since sanitary methods of refuse disposal which obviate any need for burning in the open are readily available and economically feasible for all communities.

Metal smelting and refining, internal combustion engines, and chemical and industrial operations were among the most numerous major sources of pollution reported. Lumber manufacturing, petro chemicals, incinerators, and road materials processing were cited by a number of agencies.

Except for the concern with internal combustion engines, the problem is not so much one of engineering control as it is one of economic feasibility and implementation. In many instances it is a question of time and money.

The solution of many problems of air pollution must consider all of the economic and social factors involved; however, where health is involved, the public must be protected.

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[1] Purdom, P. W., *Administration of Air Pollution Control in the United States*, Public Health Reports, vol. 72, No. 11, November 1957.

TABLE I.—*Major types of air-pollution problem conditions*[1]

Type of pollution:	*Number times reported*
Smoke, soot, and fly ash	57
Dust	7
Odors, gases, and fumes	18
No major problem	1

[1] From 1956 survey. Purdom, P. W., *The Administration of Air Pollution Control Programs in the United States.* Mimeographed. Presented Conference of Municipal Public Health Engineers, November 1956.

TABLE II.—*Major sources of air pollution*[1]

Source:	*Number times reported*
Open burning (refuse, scrap, industrial wastes)	18
Metal smelting and refining	14
Gasoline and diesel motive equipment (autos, trucks, locomotives)	12
Chemical industries (not specified)	9
Lumber, furniture, and so forth	9
Industrial (not specified)	8
Incinerators (domestic, apartment, commercial)	8
Oil refining	5
Railroad locomotives (coal burning)	5
Sulfur and sulfuric acid	4
Asphalt plants	4
Meat packing and rendering plants	4
Paint manufacturing	4
Fertilizer plants	3
Textiles	3
Laundries	3
Aggregates	3
Cement manufacturing	3
Farm products processing	3
Apartments, hotels, schools, substandard dwellings	3
Paper and pulp	2
Paint spray booths	2
Other (ammonia, rubber, lithographing, pollen, gas plant, food processing, milling, roofing, burning natural gas)	9

[1] From 1956 survey. Purdom, P. W., *Administration of Air Pollution Control in the United States*, Public Health Reports, vol. 72, No. 11, November 1957.

Extent to Which Available Control Techniques Have Been Utilized by Communities (3)—Milwaukee County

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I. Do We Now Have the Technical Knowledge Required to Control Air Pollution?

The last decade has witnessed great strides in application of scientific methods for determining qualitatively and quantitatively what contaminants are in the air. The possession of a comprehensive knowledge of air pollution and the techniques for controlling various manmade contaminants is a worthy challenge for any control officer responsible for any sizable industrial community today.

This arises from:

1. The rapid succession of new and usually better analytical methods.
2. Improved instruments for testing and analyzing.
3. Changes in industrial processes which may eliminate an old problem of air pollution or possibly create a new one.
4. New developments or improvements in pollution abatement equipment.

Industrial sources are the group which presents the greatest and most changeable variety of pollution; however, the modern industrialist exhibits pride in his plant and usually is willing to make expenditures which will make his operations acceptable and his plant a good neighbor in the community. An example in Milwaukee County is a new cement mill which is designed to utilize fly ash from pulverized coal-burning central steam powerplants. Located on a navigable waterway in the heart of the city, the plant was equipped as it was built with all the most efficient air-pollution abatement equipment which money could buy but only after a pilot-plant operation had been set up, tested, and evaluated under various conditions. Not many years ago such an installation in a similar location would have been impractical and unwise.

On the other hand, one is often confronted with the very real need for trustworthy performance, operational, and maintenance information by the small industry, which is quite willing to install new or to replace old obsolete contaminant arresting and collecting equipment provided specific assurance can be given that a certain piece of equipment will meet local requirements. Purchase, use, and maintenance may loom as a major undertaking to the small industrialist. In fact it may bankrupt his enterprise if it fails or becomes too much of a burden. The control officer is not only consulted but is often expected to help select the equipment and give it his more-than-official approval to the extent that he will thereafter be satisfied forever with its performance. This situation naturally stems from distrust of guarantees made by equipment manufacturers or their representatives and the not unwarranted assumption that the control officer should know more about such equipment than any other local individual because of his experience. Situations of this sort are not uncommon and they are potentially troublesome or dangerous for obvious reasons.

Some recent examples include:

1. Unsuitable bag fabrics in bag filter collection of iron oxide fumes from electric-arc steel-melting furnaces which resulted in the need for complete replacement of a set of nearly 600 synthetic fiber filter bags by another and more costly synthetic fiber bag after a very short period of use.
2. A horribly poor efficiency of electrostatic precipitator installation on a similar iron oxide fume from arc melting furnaces in a steel foundry.
3. Wholly unacceptable residual dust loading from wet cyclone-type collectors in an asphaltic road paving material plant which, despite a high collecting efficiency, was doomed to failure because the entering stream of hot gases carried an extremely high dust-

loading from the revolving drum aggregate heating and drying equipment.

4. A failure in a nonferrous metal reclaiming-processing plant due to condensation of moisture and ice formation in bag collectors in extreme cold weather, coupled with undue delay in stopping operations, caused considerable damage to parked automobiles. The last instance illustrates not only equipment trouble under severe circumstances but man failure as well.

Municipalities in the county have, unwillingly in most cases, created or allowed air-pollution problems of considerable magnitude to develop until confronted with county enforcement action in such matters as these:

1. Improper operation of so-called sanitary land fill dumps. Ground water and freezing temperatures render such operations impractical for organic refuse requiring immediate placement of cover material. Although one township disposed of its partially organic refuse in a privately owned dump, used by any and all haulers upon payment of fees, the township found it was on the losing end of a civil damage lawsuit, whereupon it participated in paying a considerable part of $90,000 to settle the claims of plaintiffs affected by the gases and odors from decomposing organic refuse.

2. At their own expense municipalities have been forced to make alterations and improvements to reduce emission of char, sparks, and fly ash from incinerators, most of which were units newly constructed by builders who guaranteed everything and trusted to luck or blind acceptance without stack dust-load test to "get by."

3. Street-sweeping operations and certain types of street maintenance have created dust problems. Failure to clean away sand and salt when winter and icy streets disappear contribute the kind of dust which spreads coughs and colds promiscuously. Only partial success appears in this category. Strangely enough, local health authorities pay no attention to such obviously unsanitary conditions.

4. In 1948 many municipally owned, operated, or leased burning dumps constituted a threat to the entire county. These have been eliminated except for one county dump where wood only is burned under strict supervision and two park and forestry burning areas for tree trimmings and the necessary disposal of Dutch Elm diseased trees.

5. Leaf burning and open fires or burning barrels have been stopped in all 19 municipalities for air-pollution control and other reasons, such as grass and woods fires as well as street curbing and paving surface damage.

6. Municipally owned asphaltic paving material plants are usually purchased from the same manufacturers who supply the needs of private roadbuilders The details of design of the plants do not favor effective dust collection. Dust-tight closures are apt to develop leaks. Dust-loading in rotary dryer exhaust ducts is heavy, around 10 grains per cubic foot of gases, adjusted to standard conditions. In order to get down to 0.24 grain per cubic foot or less, the collector must have at least 97.6 percent average overall efficiency. Dry collection bag filters are not

favored because of high first cost (must have tremendous size) and rapid deterioration of bags in such rough service. In cool or cold weather moisture condensation in the bag filters results in plugging. Best results to date have come from water-washed coarse fabric collectors, which fortunately are not costly.

Domestic sources of contaminants requiring drastic control are generally found in Milwaukee County in the apartment house areas where old buildings and old heating systems prevail. These are routine insofar as correction measures go since the principal nuisances are smoke, fly ash, or char from heating or incineration equipment.

Flue-fed incinerators modified or replaced are high on the list of accomplishments of a specialist inspector covering incinerators. Most flues have been converted to drop-chutes only, terminating in a fireproof, sprinkler-protected bin from which the refuse is removed and fired manually. A new or reactivated chimney flue or stack carries the combustion gases away and the incinerator is usually converted to a local standard two-chamber design with automatic draft control to aid in regulating gas velocities and in maintaining optimum furnace and secondary chamber temperatures.

On an independent basis the local version of how an incinerator should be designed was found to be almost identical with that developed in Los Angeles and with the findings of the engineering research & development section at Taft Engineering Center.

As elsewhere in the United States the availability of fuel gas has perceptively, and by dustfall tests, helped to reduce pollution load appreciably in quiet suburban residential areas. A good average for annual dustfall in such areas is now in the range of 15 to 20 tons per square mile per month which compares favorably with a range in 1950 of 20 to 25 units. The "quiet" terminology simply means an area where motor vehicle traffic is light.

Complaints from residential areas are mostly those one would expect to arise from newly annexed, newly built subdivisions where the "savages" have not yet become accustomed to the ways of modern community civilization and backyard burning barrels have sprouted. The remedy has been community collection of all refuse and orderly disposal by proper incinerator plants followed and paralleled by landfill of the ashes and stabilized noncombustible refuse. The "conversion of savages" is not without incident and does not come through a single "prayer meeting."

No mention has been made so far of the transportation field, which has several important facets such as:

1. The private automobile.
2. Urban, interurban and long-distance mass transportation buses and trucks.
3. Railroad locomotives.
4. Ships, tugs, marine work boats.

Automotive vehicle registration in Milwaukee County for 1957 was 342,666 motor vehicles. This means 1,434 vehicles per average square mile. Automobile exhausts during rush traffic hours contribute considerably to air pollution in the "downtown" congested areas; however, there have not to date been incidents of eye irritation nor other indications of animal or vegetation reaction to concentration of oxidants or oxidized hydrocarbon compounds under even the most unfavorable meteorological conditions. Geography and topography may be the prime favoring factors against concentrated air pollution. As almost everyone knows, all of eastern Wisconsin is a flat glacial plain bounded on the east by Lake Michigan. Most industrial cities in this area are lake ports. On the north the State touches Lake Superior and the upper peninsula of Michigan. West of the Mississippi River, which is the western border of the State, are the Great Plains. Therefore, there should be no surprise over the fact that average annual wind velocity is about 14 miles per hour and the prevailing direction is from the southwest. Relatively calm days when light surface winds of less than 5 miles per hour prevail are not frequent; seldom are there more than 20 such days per annum. Atmospheric turbulence is the rule rather than the exception.

In December 1956 the writer was moved to make a comparison between the automobile statistics of the county with Los Angeles County. As of that time the following data were available:

	Population, thousands	Motor vehicle registrations	Area, square miles	Density, cars per square mile
Los Angeles County	5, 200	2, 500, 000	4, 094	611
Milwaukee County	871	300, 000	239	1, 255

Statistically also, there were 2.08 persons per car in Los Angeles compared with 2.9 persons per car in Milwaukee County. Then, too, the population densities, in the same order were 1,270 persons per square mile compared with 3,650 Daily average consumption of motor fuel was not available at that time.

Mass automotive transportation here, as elsewhere, is subjected to routine spot-check observations in motion for visual exhaust haze or smoke. Although the frequency of observations is light, regular contacts at motor truck and bus centers has focused attention on the necessity for a high order of mechanical maintenance of engines. Actual cases of heavy hazing or smoke result in issuance of a returnable notice with explanation of fault, and correction as well as signatures are required. The psychological effect is good. The local bus transportation company has for 3 consecutive years won an M.E. (Maintenance Efficiency) award from the Fleet Owners' Association for low maintenance cost records per mile traveled in the local motor bus class. The local operators tell us that observations and notices have aided materially in keeping them "on their toes." High grade diesel fuel seems to be the important item in making close preventive maintenance practices "pay off" in overall maintenance costs. Similar activity is carried on with the interurban buses, the long-distance buses, and the truck fleets.

Railroads were the actual beginnings for motive power inspections. The coal-burning steam locomotives originally were one of the major sources of smoke, cinders, and fly ash. Over a period of one-and-a-half years this had been corrected to such an extent that more diesel locomotives were "turned in" than steamers, all of which disappeared some 5 years ago. The railroads immediately take a "reported" diesel out of service and send it to the shops when the inspector turns it in. More important, the crews often call for another engine at about the same time that the unit is observed to be "getting on the borderline."

Steamship power costs on the Great Lakes favor coal fuel; most ships now calling at the port or wintering here are coal burners. In

1951, after much persuasion and some memorable court cases, it was possible to witness a test of the first under-feed stoker installation, which oddly enough was in Scotch marine boilers of what was perhaps the worst-performing steamship on the Great Lakes. The installation was an unqualified success. At least 40 steamships have now been converted to the under-feed stokers with fully automatic controls of simple but effective type. The conversions in most instances, depending upon how busy the ship is, have been paid for out of increased sailings and an average of 10 to 15 percent reduction in fuel consumption. In addition they are not limited to closely selected fuel as was the case with other methods of firing. Naturally the fly ash problem also diminished to a negligible amount; on a visual basis it was probably a small fraction of that permitted for stationary plants.

The large ore carriers do not dock in Milwaukee except for rough seas and for winter "lay-up," which is followed by spring "fitting-out." One ore fleet brings 16 to 20 ships into the mooring basin, many of which are spreader-stoker coal fired. These units smoke badly at light load. The marine inspector exercises close supervision over them and has them arranged so that steam piping connections between moored ships make it possible to furnish steam for three ships from one boiler of the ship on alternating days. With something approaching a "good steam load" this reduces the smoke problem down very materially, in fact, quite closely in line with the ordinance requirements. With such practical means of complying with the ordinance and a saving in personnel in the boiler holds, the fleet operators are more than willing to cooperate.

II. In Areas Where There Is Now an Air-Pollution Problem, Is Technical Knowledge Being Used Effectively?

In general, technical knowledge as it has been developed locally has been used effectively. Each community has somewhat different individual problems; the complex of them is likewise bound to be different. There is a preponderance of Milwaukee industries where highly skilled workers predominate despite the prevalent notion that nothing but beer and baseball occupies the working population.

However, there are no steel mills or petroleum refining, no heavy smelters, and almost no secondary smelting.

The general policy has been to refrain from strictly mechanical technical regulations as much as possible but with emphasis on performance at least equal to the minimum standard presented by ordinance and with the assurance that full-scale stack testing will be made of every fuel-burning plant. From this performance standard basis, certain techniques have been evolved and recommended in no uncertain manner but the door is not closed on techniques which contractors, owners, and operators wish to use with the understanding that "they are on their own" and may be required to modify a design or construction at once if it does not meet performance standards. It is our conviction that no individual in the air-pollution control business has all the technical knowledge necessary to approve or reject plans and specifications unless it can be shown beyond the shadow of a doubt that the construction proposed is faulty. As a result our recommendations are based on practical, proven facts and are well accepted rather than appealed.

Technical appeal bodies are not apt to possess any more knowledge of the factors which assure minimum emission of air pollutants than the department itself possesses. Technical appeal boards may not, and often do not, share the primary responsibilities which the air-pollution officer and his staff have for ultimate results. More persons conferring on a given design problem are apt to have just that many more divergent views and it is almost impossible to establish hard and fast rules which all will agree upon. The overall responsibility may well become diluted; personalities and friendships may prevent placing the responsibility for performance where it belongs, in the "lap" of the owner-operator.

Further application of tried and proven existing control methods is and will always be necessary. However, even pilot plants do not necessarily perform in the manner which characterizes the full-scale operation.

Improvements in existing air-pollution-control methods which are uneconomic or which are at best not as effective as they should be are the crying need of the day. Much can still be done to make the arresting and collection of open air contaminants a less burdensome, or even a profitable, adjunct to industrial operations.

Further research on control methods is necessary in the fields of:

1. Methods which assure maximum completion of combustion of fuels.

2. Processing of fuels which are conducive to economic use and which are the best suited to the various uses to which fuels are put. There are still many instances where present day fuels are not used to the best advantage in conjunction with the fuel-burning equipment. Examples are numerous:

   Solid fuels, having appreciable volatile content, fired by hand or mechanically in a manner imitating manual firing.

   The "premium" fuels, gas and oil, used for purposes where their ultimate scarcity of supply and high cost will hasten the day when wholesale conversions will make air-pollution problems a "wholesale nightmare." Briefly, this is a resource conservation.

   Automotive fuels which are clean burning, and do not require "additives" to prevent knocking in the internal combustion engines, which today in the aggregate develop more power and exhaust more contaminants into the atmosphere than all other forms of power units.

III. Whose Responsibility Is It to Sponsor Development and Research on Source Control?

This is indeed a far-reaching question and needs to be examined from many points of view.

1. Existing trade associations have undeniable technical competence to assure the users of their members' products that air pollution in a certain line of equipment, within prescribed uses, is thoroughly minimized. The small household incinerators meeting the label approval construction standards of the American Gas Association are an outstanding example. It is noteworthy that the technical advice of the coal industry through the Bituminous Coal Institute has moved in the direction which should keep users of that fuel out of many

difficulties which they have been prone to accept. Although hampered by chrome plated strips and tail fins, there appears to be a movement toward at least a more economical use of fuel in the automotive industry.

2. Sources of air pollution are in general dependent upon local community conditions insofar as their characterization as "nuisances" is a matter of public concern. Unless and until such a nuisance reaches, or seems bound to reach, another community it would seem that the community itself is the proper unit which should assume the responsibility.

3. Where several political subdivisions are affected by the nuisances it is a matter for mutual agreement, and a control authority, actuated and empowered to act for the group, appears the obvious choice.

4. However, in many areas it seems clear that compacts between one or more States is the obvious solution. In stream pollution the group of States comprising the Ohio Valley Stream Pollution Compact is a good example except for the fact that 20 years of time and Federal assistance were required to "get the show on the road."

5. A time-honored custom in these United States is for a political subdivision to shift its problems (especially where no revenue is recoverable) on to the next higher echelon of Government. Obviously this shifts the cost burden as well as the responsibility; however, every political subdivision has its representation in the Federal legislature and therein lies the temptation to achieve the maximum service at the least possible local cost. In matters of national concern the answer to the question is obvious. The test is whether or not a local problem is really of national concern. It seems that no one individual or political subdivision can supply the answer in toto and that the representative democratic processes of all the States must be relied upon.

True, the thinking in connection with Federal participation is in the realm of research and development: in no instance thus far has Federal administration and enforcement at the local level been considered. The actual question which must ultimately be anticipated—in the light of national health aspects, as affected by air pollution, specific data on which may be forthcoming—is whether or not research and development should be integrated with nationwide law, rules, regulations, and enforcement.

DISCUSSION

GUY T. MCBRIDE. With regard to flue gases from large-scale combustion operations, what is the current acceptable SO_2 concentration? To what concentration can SO_2 be reduced by proven industrial processes? What research is in progress to reduce the SO_2 concentration?

Mr. WILLIAMSON. I don't believe that an answer can be given to the first two questions. What the currently acceptable SO_2 concentration is, nobody knows. As to what concentration SO_2 can be reduced by proven industrial processes, there has been comparatively little industrial-scale adaptation in this country. The English have done it, but as Mr. Ballman said this morning, the cost is something on the order of $4 to $6 a ton of coal. I wouldn't say that that is a proven industrial process. That is a pilot-scale test.

What research is in progress to reduce the SO_2 concentration which can be achieved? I think there is a good deal of work being done in Chicago. The bituminous coal research people are working on that, partly supported by a grant from the Edison Illuminating Co., but the work has just started. Someone here may know of some SO_2 work being done with ammonia gas or other processes. It is a very moot point as to what should be done, and it is a difficult one to say what can be done.

Mr. Ballman. One more point on SO_2. People hereabouts are attempting to recover sulfur from effluent gases as they do in Western smelting operations, where you have high concentration of sulfur or sulfur oxides and get a sufficiently good recovery to pay for the system over a long period of time. When you get into the boiler gases, the effluent oxides of sulfur are so thin there is very little of it to recover as compared to other processes. You can't carry corrective measures from these plants in the West back to public utilities in the East, and I think sometimes we are prone to do that. I'd like to make this point: do you have enough sulfur in the gases or do you just have a little bit?

Dr. Silverman. I doubt if we want to get involved in SO_2 concentration, because it is gross emission per hour or day you are going to assign to a particular flue. If you are talking about concentration alone without considering the total cubic feet of emission, you could get a higher concentration from a refrigerator than you would a flue gas.

Mr. Chalker. To put it another way, the proof of the pudding is what SO_2 does to the environment. We have run into this problem in vegetation damage, in which we are searching for a criterion of how low these values should be. We have found that the SO_2 concentration out around the crops, if it exceeds about two-tenths of a part per million for 8 hours or 1 part per million for 1 hour, it will damage vegetation. We have used this as a criterion shifted to lower sulfur fuels to solve this.

W. W. Hodge. The Manufacturing Chemists' Association's Air Pollution Abatement Manual has several examples in it giving the SO_2 concentration permissible in a number of cities in the United States and most of those had 10 parts per million. Whether that would be the allowable limits from stack or whether that's toxicity, I don't know.

Dr. Silverman. That is the maximum allowable concentration for 8-hour day exposure, and, if used as a criterion for stack concentration, would imply that you ought to make every stack safe for somebody to put his head in. I think the question is aimed at what flue gas concentration is admissible.

Mr. Hodge. The manual also stated that SO_2 was much more detrimental to certain types of plants than to others. I suppose you are going to base premissible limits on the allowable concentration of SO_2 on humans, that is, its effect on humans rather than on plants.

Dr. Silverman. It depends on the kind of plants you are talking about, on who is making the limits, and who is interpreting the effects. The limit, for example, for H_2S is beyond anything people can detect by odor or sensory response, but they can claim a lot of damage from small amounts of H_2S.

Mr. Hodge. I thought they were talking about SO_2.

Dr. Silverman. It's in the same category.

Mr. Hodge. The other has more toxicity.

Dr. Silverman. They are both of comparable toxicity. Both have a lethal dose of 4 to 5 parts per million and maximum allowable concentration of practically the same amount.

Mr. Hodge. In the meeting I was in a short time ago they stated that people in Delaware were complaining about the odor of oil refineries, and I wonder if they have done anything to alleviate that air pollution problem.

Mr. Burroughs. We don't operate any refineries up there so I shouldn't answer the question. However, from what I know of Tidewater's plant, odor control is very good there, but I will point out that every oil refinery has an odor. I worked for 20 years in an oil refinery, and I think an oil refinery smells wonderful, so I think it's the opinion of the individual.

(Unidentified). Mr. Burroughs included in his talk on economic aspects figures spent at Tidewater's new refinery in Delaware. He mentioned $2,500,000 of which we at Tidewater attributed $1 million, with no return at all, to odor problems. We do have possibly ground-level odor problems that we are working on right now and have done a substantial amount of work on reducing those.

Mr. Chass. I remember, about 2 years ago at an API meeting, when the chairman of the Smoke and Fumes Committee included in his paper remarks to the effect that you should not be able to see a refinery, hear a refinery, or smell a refinery.

Mr. Roberts. I want to return to SO_2. I think there is a Canadian report on SO_2 which stated exactly what the difference was between the western conditions and the eastern.

(Unidentified). Returning to sulfur dioxide and the large combustion operations, we had some comment about what to do to control it coming out of the stack, but little comment about what could be done to prevent it from getting into the stack in the first place. The oil industry has found it desirable to reduce sulfur content of Number 2 fuel oils. This, while perhaps done for other reasons, tends to reduce sulfur dioxide coming out of the stack. Has the panel any comment on reducing the sulfur content of other types?

Mr. Williamson. Coal beneficiation has been practiced for decades in effectively reducing sulfur. Southern Illinois coal can be beneficiated from as much as 3½ or 4 percent sulfur down to 1½. Other coals don't respond as readily to work as does southern Illinois coal because of the difference in the sulfur content.

The research project by Bituminous Coal Research Institute includes coal beneficiation as a way of reducing the sulfur discharge. Incidentally, when I said that there was no known limit to permissible discharge, I was referring to SO_2 in the flue, since that was the original question. As we heard from Mr. Chalker, there are known limits of SO_2 at the ground, but you are very right; if you can eliminate it in the fuel in the first place, you don't have to eliminate it in the stack, and this would seem to be for many fuels a better approach.

Mr. Chass. I would like to read for your information the opening sentence in Rule 62, just passed in Los Angeles County, in which it says that it will be unlawful to burn anything within Los Angeles County between the dates of May 1 and September 30, both dates inclusive, during the calendar year 1959, and each year thereafter between May 1 and October 31, any gaseous fuel containing sulfur compounds in excess of 50 grains per hundred cubic feet of gaseous fuel, or any liquid fuel having a sulfur content in excess of 0.5 percent by weight.

I agree it is best to take care of what goes into the combustion process. I would also caution against the advisability of attempting here to establish standards of SO_2 concentration at ground level that would be applicable to all areas of the country. On this line, many years ago we passed a rule which established the SO_2 emissions at 0.2 percent by volume.

For years compliance with this rule prevented SO_2 damage to vegetation in the vicinity of any powerplant or large user of fuel oil. Lately, however, we have been experiencing SO_2 damage, and this needs another look.

I believe that the meteorological conditions play a most important role in whether or not you are going to get vegetation damage and whether or not there's going to be a nuisance to people living in the nearby vicinity.

Mr. BURROUGHS. We are getting into the field of refinery technology here. The reduction in the sulfur content of Number 2 fuels or Number 3 or Number 4 fuels can be carried out and is carried out, in the case of Number 2 fuel, by hydrogenation, using a catalyst. This treatment converts the sulfur compounds in the Number 2 fuel to hydrogen sulfide and they are taken off then as a gas.

However, Number 6 fuel, that is, the heavy type of fuel we have discussed here, is a residual fuel. It is what is left after you distill everything else off. It does not lend itself to any type of known economical treatment for the removal of sulfur. The oil industry spends a great deal of time on this problem.

I mentioned earlier that available crude oils are becoming higher and higher in sulfur content. This has become more and more of a problem to the oil industry.

I should also like to correct a little confusion that seemed to have originated from a statement Mr. Ballman made with regard to the SO_2 problem in the East and in the West. We have discussed what has been done in Los Angeles. The same thing is being done all over the country by the oil industry. We are not in the West removing sulfur from flue gases. We are scrubbing the fuel gases for removal of hydrogen sulfide before they are combusted. This is an entirely different matter from removing sulfur from the flue gas itself. In England, as Mr. Williamson mentioned a while ago, they have removed SO_2 from flue gases. They have done this, I believe, by scrubbing the flue gases with large amounts of water. Of course, this results in a stream-pollution problem, and efficiency is very poor. As you know, flue gases not only contain SO_2 but also are bearers of large amounts of carbon dioxide, which is an acidic material.

If you scrub flue gases with water or with any alkaline chemical which will remove the SO_2 you likewise remove CO_2 to a large degree. This makes any type of scrubbing operation a very expensive matter.

Mr. BALLMAN. I made no reference to refineries in my statement. I was referring to western reduction plants, so there is no confusion.

HARLOW W. CHAPMAN. Will Mr. Chass elaborate a little further on SO_2 damage and where it was and in what concentration?

Mr. Chass. The pathologists claimed that the identification of SO_3 damage to vegetation is quite distinct from that of SO_2. SO_3 damage is downwind from powerplants burning fuel oil. I don't have at my fingertips the concentration that has been measured through atmospheric monitoring. Some question has been raised as to whether a distinction can be made between SO_3 damage and sulfuric acid damage. Some authorities state that the initial burn is SO_3, and in periods of high humidity, it produces a sulfuric acid burn.

Mr. Ballman. We seem to have a difference of opinion on one point at least. You say you have Rule Number 62 that has gone into effect, but I hear you have corrected that, and it now eliminates all heavy oil.

Mr. Chass. What do you mean by heavy oil?

Mr. Ballman. Number 6 fuel oil.

Mr. Chass. Call it anything you wish as long as it doesn't have more than five-tenths percent sulfur.

Mr. Burroughs. If I understand the ruling correctly, vehicles—that is, ships and all other types of vehicles—are excluded from this ruling and may use whatever fuel they may have been accustomed to use. Insofar as utilities and refineries and so forth are concerned, it looks as though our problem is going to be solved by burning gas.

Mr. Ballman. This changes the economy of energy in your area, talking about specific cases now. One factor I didn't mention during my presentation was the fact that this immediately places a burden upon the individual citizen, so that he can now buy all the air-pollution control he wants.

Dr. Silverman. It's fair to say that the oil industry on the west coast did not accept this with enthusiasm.

Mr. Ballman. I am thinking of the economics of controlling fuel. We have a difference of opinion.

Mr. Burroughs. We opposed this ruling because there are times in operating a refinery when you are long on heavy fuel oil and when you want it for fuel. If you can't do that and your tanks are running over, it puts you in an embarrasing economic situation.

Mr. Chass. To set this straight, we found that some of the oils that you call light, according to the area, contained 1½ percent sulfur, so that any attempt to use numbers or labels like "lights" or "heavies" for this purpose would not suffice. As to the economy of the area, we are not economists, and have never claimed to be, but as to whether or not we have changed the complex of the area, I would like to read one of the exceptions to the rule before we go any further, just the first sentence.

> The provisions of this rule shall not apply to the use of liquid fuel whenever the supply of gaseous fuel, the burning of which is permitted by this rule, is not available to the user through accident, act of God, act of war, act of public enemy, or failure of the suppliers.

One question that was raised was what happens if the pipeline breaks.

Dr. Johnstone. All of us at this conference are here for one purpose only, and that is to discuss the prevention and alleviation of damage to health or well-being by air pollution. One of the things that we know has been contributing to severe episodes where deaths have occurred, is sulfur dioxide, and its oxidation product, specifically, sulfur acid, especially when certain irritants are present. Clinical investigation of these episodes has shown definitely that concentrations of sulfuric acid and sulfur dioxide have probably existed, and work at Harvard University now going on is showing dramatic effects of very low concentrations of sulfur dioxide in the presence of substances that we know are present in the air of cities in the United States.

I'd like to read some data which I copied from the General Electric Co. report Number 56 RL 1640, on atmospheric products, and the role played by combustion products. I shall not read all of the data, only a few. You may get that report from the General Electric Co. I will read only the concentrations of sulfur dioxide, the maximum concentration. Central London sites in 1952 smog, when 4,000 deaths occurred within a few days, maximum concentration of 0.56 parts per million SO_2. London sites in 1948 smog, .31 parts per million SO_2. Pittsburgh, industrial area, 1932, .5 parts per million SO_2. In Donora, during smog, 1948, in the Bulletin of the U.S. Public Health Service the estimated concentration of sulfur dioxide was 2 parts per million.

There are substances present in the air which nucleate fog. We have shown in the laboratory that within 2 minutes after the formation of the fog, serious toxic concentration of sulfuric acid will be formed from low concentrations of sulfur dioxide. Remember those data, and remember that serious consequences have been caused by the presence of sulfur dioxide in the atmosphere. Need we ask what it cost?

Dr. **Silverman.** I don't want to deprive anybody of their right to reply to Dr. Johnstone or to reply to anything that was stated here that they are in disagreement with.

I am not disagreeing with Dr. Johnstone. I am still openminded. I am not interpreting the Harvard data he mentioned at this time. Most of the work that we have that is interesting along these lines is still in the guinea pig realm.

Dr. **Johnstone.** I can read the data from the manual.

Dr. **Silverman.** I know the data, but the nucleating data are in the guinea pig stage.

Dr. **Johnstone.** Mine are on acid formations.

Dr. **Silverman.** Dr. Johnstone at any rate has an interesting point here, and if we are going to accept as a discussion point whether or not we have technical knowledge on air pollution as applied to SO_2 I think the answer again is one I made earlier today. It is one of economics, that is, whether it is cheaper to switch fuels or whether it is cheaper to switch processes. These are important points.

Joseph Goldfield. I have been listening to some of the discussions from the viewpoint of application to engineering, and it has been discouraging. There haven't been too many criteria laid down that I can lay hold of. Some of the problems that have been discussed are interesting, but an engineer who has to apply methods to air-pollution problems is confronted by not only one or two problems, for instance, SO_2 or fly ash, but any one of literally hundreds of problems, and some of the discussion has raised questions and provided no answers. For example, we have no method of measuring particle size although particle size is essential in solving problems, and so on. On every problem that was raised it was pointed out there are difficulties in getting any criteria for solving them. Even the maximum allowable concentrations are not known, either on solids or gases. The only criterion we have been given is to copy installations that have been successful. This is all right, but the air-pollution men have pointed out that they are very reluctant to give out information on installations that they consider successful, perchance for fear of making an error.

That leaves us in a difficult position. We have to suggest a solution to the problem, and I would recommend that, since our only practical approach seems to be the very pragmatic one of copying successful installations, some attention be given, especially by the air-pollution men, to publicizing the installations that have made progress. They should not confine it to articles in the literature, but possibly compile a list of the thousands of installations that have been making some progress and circulate it among engineers who are interested in solving problems. Some of this work may have been done.

Dr. **Silverman.** You have stated a point, but I don't quite agree with it. I think we have a lot of answers to the things you think we don't have answers to. We did not intend on this program to air them all. For example, in answer to your last point, Mr. Chass has a rather complete list of successful installations. I think we can cite chapters in many cases, also, but we are pointing out the frontiers where economics are important. In many cases the cost of these installations that would fit fine in Los Angeles would drive iron foundries out of business in 45 other States. This is the sort of thing that fits in one locality and not another.

So I don't think you can paint everything with the same brush. I hope we haven't implied in this discussion that this is possible. There are variations within limits, because of terrain, meteorological conditions, types of raw materials, and any number of other factors; so to attempt to tie them all together is asking a lot more than our present knowledge will permit. It is true we can put the best kind of cleaners on any kind of process and make them work successfully and economically. I think that is a point that calls for more and more engineering development.

Mr. **Chass.** I agree with part of Mr. Goldfield's statement, and in part I agree with Dr. Silverman. I think a great deal of data on control installations have been published. Some data have not, simply because the controls that have been adapted to the particular installations haven't been perfected. This has been a job all engineers have had, getting material published, because you always have many more things to do than publishing your work. Along this line, we are now writing a manual on air-pollution control that we hope will benefit the designer, the superintendent, and the control officials. I hope that it will be finished some time next year. It will be quite thorough.

DISCUSSION GROUP "F"
ADMINISTRATIVE ASPECTS

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Theme

"Community Responsibilities in Air Pollution"

Questions for Discussion

I. What are the respective responsibilities of the individual, public agencies, and industry, in the control of air pollution?
II. In general, in the conduct of air-pollution-control programs—
  (*a*) Should air-pollution control be organized on a local basis? Regional? State? Other?
  (*b*) What relative emphasis should be placed on education, voluntary action, regulation, legal enforcement?
  (*c*) What is the role of zoning in air-pollution control?
  (*d*) How should air-pollution control be paid for?
III. What place should concern for health have in an air-pollution-control program?

Levels of Responsibility for the Administration of Air-Pollution-Control Programs

Harold W. Kennedy
County Counsel, Los Angeles, Calif.

I. INTRODUCTION

Long before the advent of air pollution, Aristotle said that "the state comes into existence so that man may live. It continues that he may live well." The responsibility of government in air-pollution control has been recognized for hundreds of years. Long before Blackstone's time, it was recognized that the law of nuisance was not adequate to take care of the situation in an urban community where there were a number of sources of air pollution. As early as 1306, a royal proclamation forbade the burning of coal in London because of the dense smoke it produced. In 1661, John Evelyn wrote a book on the smoke nuisance in London.[1] His remedy was quite simple. All industry was to be moved to the leeward side of the city and sweet-smelling trees planted in the city. With the growth of cities and with the multiplication of industrial plants, it became increasingly difficult to prove that any particular defendant was guilty of a nuisance. Indeed, it is of the very essence of the police-power concept that a government possessing such power has the responsibility to protect the health, safety, and welfare of its citizens. Inherent in government is its primary responsibility to protect the people.

Today, public agencies at all levels admit to some obligation in this field. Yet it can be said in complete fairness that this late in the 20th century few have taken more than tentative steps toward an effective program of air-pollution control. A fortiori, this Nation does not have a coordinated overall plan or framework of organization for combating air contamination.

Let me make it plain that when I speak of a national air-pollution program, I am not referring to a federally executed program. Rather, I mean an all-American campaign involving every level of government, and also support from contributing private industries and, of course, the public. This paper deals largely with the responsibility of Federal, State, and local agencies in the administration of air-pollution-control programs. However, to be effective, a successful air-pollution-control program must involve the active and aggressive cooperation of private industry and affected citizens.

If air-pollution control nationwide is to be effective, contributing industries must assume their rightful place in waging all-out war against the modern plague of smog.

Public Versus Private Responsibility

To put the matter into sharp focus, it is my firm opinion that the primary responsibility in controlling air contamination is squarely upon the shoulders of those who produce it. This is true both morally and practically. For example, the people who consume electricity cannot control emissions from stacks of steam powerplants. The individual motorist can no more control the emissions from his car's exhaust than he can stop breathing, unless he stops driving.

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[1] "Fumifugium: or The Inconvenience of the Aer and Smoake over London Dissipated." Reprinted by the National Smoke Abatement Society, London, 1933.

This latter condition is worthy of special consideration. In the county of Los Angeles it is an accepted fact that the motor vehicle exhaust is the major uncontrolled contributor to our now world-famous smog. In our sprawling metropolis the automobile is the only useful means of transportation, and southern California represents a vast market for the motor vehicle manufacturers. One would think that the automobile industry would be gravely concerned, and launch an all-out crash program to tame the lung-searing, eye-smarting monster which its ingenuity has unwittingly created. The pitiful truth is that months and now years have passed since that industry was confronted with the indictment, and to date our automotive experts have received no substantial evidence that any such all-out program has been activated.

For several years the Board of Supervisors of the County of Los Angeles has strongly urged the automotive industry of the United States to accelerate its activities in the field of research in order to sharply reduce the emissions of hydrocarbon resulting from automobiles. In October of this year, the scientific team representing the major automobile manufacturing companies of the United States gave a public report to the people of Los Angeles County as to what they have accomplished to date. It was generally agreed that the report was most disappointing and not at all encouraging as they were unable to outline any prospective time schedule when the more than 6 million people in Los Angeles County could look forward to the development of a device that had been thoroughly tested and found effective to cut down hydrocarbons from automobiles using petroleum products. From this report it is apparent that the automobile industry, despite its vast resources and its outstanding scientific and engineering skills, has thus far been unable to find the proper answer to this perplexing phase of air pollution. It was publicly admitted that altogether the automotive industry was not spending more than a million dollars a year, which, of course, could not be considered an urgency program, a "Manhattan project" designed to protect as soon as possible the health and comfort of the people living in the midst of the automobile jungle that is so characteristic of all metropolitan areas. The report from the automobile companies was particularly disappointing because of the recent official report made by the Department of Public Health of the State of California published in the annual report issue, the Clean Air Quarterly, volume 2, No. 1, March 1958. This report was prepared under the direction of Malcolm H. Merrill, M.D., director of public health for California, and it included the following:

> Prospects for a further sharp reduction in air pollutants in Los Angeles are poor until a control device for motor vehicle exhaust is available. Because adoption of regulations and installation of control devices take time, it will be a few years before pollutants from sources now under control in Los Angeles will be appreciably reduced in other parts of the State also.

* * * * * * *

> *Research indicates that eye irritation and crop damage are related to automobile exhaust. Automobile exhaust is also known to be associated with the liberation into the atmosphere of substances which in the laboratory are known to cause cancer. It would be a tragic mistake to be content with the elimination of eye irritation only to find, in a decade, that our populations had been exposed for years to cancer-producing substances in quantities capable of producing disease. By that time preventive measures would be too late.* [Emphasis added.]

The people suffering from aerial sewage in Los Angeles County and in California had every right to have expected greater interest, cooperation, and accomplishment from the automotive empire of America in developing improved carburetion, some type of an afterburner, or improved exhaust, or maybe a catalyst to reduce health-menacing hydrocarbons from millions of automobiles overrunning our State. Free enterprise is truly the keystone of democracy, but free enterprise without responsibility endangers itself and us all.

II. STATE AND LOCAL PROGRAMS

Constitutional Basis

In a constitutional form of government such as we enjoy in the United States, it is paramount that consideration first be given to the constitutional problems involved in any control program. How can a city, county, State, or combination of any of them bring to bear its powers with the objective of controlling air pollution?

The only basic limitations on the police power of the States—and this residual power of the States includes the power to protect the health, safety, and general welfare of their inhabitants—is the Constitution of the United States. The 10th amendment to that document provides as follows:

> The powers not delegated to the United States by the Constitution nor prohibited by it to the States, are reserved to the States, respectively or to the people.

The police power, of course, is not a completely boundless one. For example, the 14th amendment to the U.S. Constitution provides, in part, as follows:

> * * * nor shall any State deprive any person of life, liberty or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the law.

Under this amendment, if legislation is adopted regulating smoke or other forms of air pollution, and the legislation is reasonably necessary for the public welfare, it will be interpreted as a valid exercise of police power. Of course, it must not be arbitrary or oppressive or unduly interfere with private business (*Lawton* v. *Steele*, 152 U.S. 133, 38 L. Ed. 385). But it is not invalid merely because it might put someone out of business or requires a large expenditure of money. As said by the U.S. Supreme Court in the leading case of *Northwestern Laundry* v. *Des Moines*, 239 U.S. 486, 36 Sup. Ct. 206, 60 L. Ed. 396:

> So far as the Federal Constitution is concerned, we have no doubt the State may by itself, or through authorized municipalities, declare the emission of dense smoke in cities or populous neighborhoods a nuisance and subject to restraint as such; and that the harshness of such legislation, or its effect upon business interests, short of a merely arbitrary enactment, are not valid

> constitutional objections. Nor is there any valid Federal constitutional objection in the fact that the regulation may require the discontinuance of the use of property or subject the occupant to a large expense in complying with the terms of the law or ordinance.

Basically, then, the State, itself, or the State acting through an adequate political agency, has power to enact reasonable air-pollution-control laws for the protection of the public health, safety, or welfare.

State Action

Whether it is feasible for the State itself to take an active part in an air-pollution-control program is dependent upon the locality involved. Some States are smaller in size than many of the counties in California. Where the area is relatively small, the practical approach to the problem is probably through a State control authority. Where great distances, widely separated areas, and differing meteorological conditions are involved—such as between the Los Angeles area of California and the San Francisco area, a distance of 500 miles—it would be impractical to have the State itself attempt the primary function of local control. A recognition of this fact is shown by a study of actual air-pollution-control areas throughout the Nation.

In 1947, California pioneered the Nation and adopted a statewide air-pollution-control statute, but left the actual enforcement to local air-pollution-control districts on the county level (Ch. 632, Calif. Laws, 1947). This type of enabling act was adopted in 1952 by the State of Kentucky (Ch. 53, Laws of Kentucky, 1952). In rapid succession other States joined the parade of statewide air-pollution control: New Jersey (1954), Massachusetts (1954), Oregon (1956), Washington, Delaware, New York, and Florida (1957).

The avowed purpose of such State statutes is to maintain a reasonable degree of purity of the air resources of the State consistent with public health and welfare. Air pollution is generally defined in broad terms as the presence in the atmosphere of air contaminants, put there by man, in quantities and of a duration to cause discomfort to a substantial number of citizens, or which are injurious to human, plant, or animal life or property. Standards as to quantity or quality of pollutants, as well as the basic framework for enforcement machinery, are usually set forth in the State statute.

The California law provides, for example, that "air contaminant" includes:

> * * * smoke, charred paper, dust, soot, grime, carbon, noxious acids, fumes, gases, odors, or particulate matter, or any combination thereof (sec. 24208, Health and Safety Code);

and

> * * * That it is necessary * * * to provide for air-pollution-control districts in those portions of the State where regulations are necessary and feasible to reduce air contaminants in order to safeguard life, health, property, and the public welfare and to make possible the comfortable enjoyment of life and property (sec. 24199, Health and Safety Code).

The act then provides for an air-pollution-control district in each county to be activated only if the board of supervisors of that county finds that air pollution is a problem and that local ordinances cannot adequately handle the problem (sec. 24205, Health and Safety Code). The board of supervisors, sitting as an air-pollution-control board, is vested with power to make all needful rules and regulations necessary or proper to accomplish the control and/or abatement of air-pollution activities (sec. 24260, Health and Safety Code). An air-pollution-control officer appointed by the board is empowered to enforce the rules and regulations adopted by the board, as well as State laws on the subject (sec. 24224, Health and Safety Code). In 1949, the California Air Pollution Control Act was amended to provide that any counties activating air-pollution-control districts could by appropriate action merge or consolidate them into an overall air-pollution-control district.

These statutes were admirably suited to a one-county problem. However, the California Legislature in 1955 created a special district to cope with the problem of air pollution in the San Francisco Bay area. The area includes nine counties.

> The problems of air pollution are primarily regional and dependent upon factors of weather, topography, population, transportation, methods of waste disposal, and agricultural and industrial development. These factors vary greatly from area to area. The San Francisco Bay area, with its permanent temperature inversion layer, presents a special problem, distinct from that found in the remainder of the State. This chapter is enacted to provide a special district to control and suppress air pollution in that area.
>
> Since the problem requiring this legislation is local and special due to atmospheric and geographic conditions, a general law cannot be made applicable so as to insure its effective alleviation. It is necessary, therefore, to create, by special law, an air-pollution-control district which includes only that area within the boundaries of the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma (sec. 24346.2, Health and Safety Code).

In addition, California adopted in 1955 a program recognizing a statewide responsibility and designed to supplement local activity in research upon the health effects of air pollution. Section 425 of the Health and Safety Code provides:

> The State department of public health shall maintain a program of air sanitation, including, but not limited to:
>
> (a) The conduct of studies to determine the health effects of air pollution;
>
> (b) The determination of the physiological effects of air pollution upon plant and animal life;
>
> (c) The determination of factors responsible for air pollution;
>
> (d) The monitoring of air pollutants;
>
> (e) The development of administrative means of control of air pollution in emergencies;
>
> (f) Assistance to local agencies in effectuating all of the subdivisions of this section.

It is apparent then, that, in some States at least, statewide recognition of the problem through appropriate enabling acts and other pertinent legislation is essential to a uniform and comprehensive treatment of the problem of air pollution.

Delaware and Oregon are examples of States which have gone beyond the mere enabling act stage on the State level. In both States, the State itself has created a statewide air-pollution-control body which is responsible for making rules and regulations on the subject and provides machinery for statewide enforcement. (Oregon Revised Statutes, secs. 449, 705, et seq., 1956; Laws of Delaware, ch. 152, 1957.) The regulations of the Oregon Air Pollution Authority, however, do provide for the encouragement of local control programs. Indeed, Oregon expects cities to maintain local programs wherever feasible, with technical assistance from the State body.

States vary, therefore, in the responsibility they have accepted for the control of air pollution. Some States have not accepted any responsibility, but have left the matter completely to local authorities. In States whose economy is substantially dependent upon heavy industry, responsibility has been accepted, for the most part, to provide enabling acts or other pertinent legislation for the encouragement of local control programs, plus the creation of standards by which such local programs may operate. Finally, some States, such as Oregon and Delaware, have provided for statewide enforcement of air-pollution laws and regulations while not excluding local action.

Local Programs

Historically, smoke ordinances have been considered the exclusive province of the industrialized city. Mills and factories which grew up in the cities during the 19th century, and multiplied and expanded many times during this century, were looked upon as the major, if not the only, problem in air contamination. Sometimes, indeed, it was a source of pride to a city to witness the erection of several new smokestacks which soon belched dense black smoke into the city's air. Ultimately, however, it became apparent that such smoke and other pollutants in the atmosphere were a costly nuisance to the public, if not a danger to public health. It was inevitable that local ordinances be adopted providing criminal (as well as some civil) remedies.

Recently it was estimated that 9,500 communities in the United States had local air-pollution problems, but only 2,050 had adopted any legislation aimed at controlling the problem (8 Baylor Law Review 249, 1956, citing the report of Arthur C. Stern). Doubtless, only a small minority of the latter number enacted comprehensive programs, and yet local ordinances account for 80 percent of the control programs in the Nation today (Summary Report to the Governors Conference, May 1958, p. 22, published by the Council of State Governments).

Air-pollution legislation is of two general types or sometimes a combination of both: (1) mere punitive ordinances setting up degrees of penalties for violation of antismoke laws; and (2) regulatory ordinances having as their object the abatement of air pollution by prevention of the discharge of pollutants into the atmosphere.

Smoke, of course, is still the primary contaminant at which the legislation is aimed. Few ordinances control gases, fumes, and other industrial emissions.

Punitive ordinances were relied upon for years by many cities throughout the Nation, but a growing realization that such legislation failed to strike at the heart of the problem has turned the tide in favor of ordinances which attack the situation at its source.

The largest city in the Nation, New York, in 1952 instituted a department of air-pollution control. A board of air-pollution control was established with power to promulgate, adopt, and amend rules having as their purpose the control of air pollution; such rules have been adopted and they provide for the control of emission of air contaminants and the construction, alteration, and conversion of all equipment capable of producing air contaminants through a permit provision; further provision is made for shutting down equipment operated without a permit and for the granting of variance from the rules and regulations.

Smoke ordinances which had been enacted in 1927 by the city of Baltimore were amended in 1956 to regulate and control the pollution of the air within the city limits by the creation of a division of smoke control under the supervision of a smoke-abatement engineer. The ordinance sets up a comprehensive program of regulation, including permits and inspection procedures. Similar programs have been adopted in Richmond, Va., and East Chicago, Ind. These cities, of course, have prudently profited from the experience of Pittsburgh, Cincinnati, St. Louis, and other localities in the adoption of effective air-pollution-abatement programs.

Many areas have discovered, however, that air pollution cannot be adequately coped with within the confines of a city's boundaries. Los Angeles is among these cities. Merely to superimpose a chart showing the prevailing wind currents over a topographical map of Los Angeles County wherein the boundaries of its 61 cities are delineated, would make it abundantly clear that an air-pollution program limited to the city of Los Angeles would be almost completely ineffective. Surrounded as it is by dozens of other incorporated communities, Los Angeles found itself dependent on their cooperation for the effectiveness of many control measures.

Cincinnati, faced with a similar situation, contracted with nearby communities in an air-pollution control compact.

The other alternative solution to such a problem is that adopted by the California community: seek State legislation providing for the creation of an air-pollution-control district at a higher political level than the individual city or county. The California law provides for the creation of such a district in each county or combination of counties. Thus, the responsibility is vested in a body which, by reason of its rather large geographical area, can more nearly control the problem in spite of the vagaries of the wind and the existence of political boundaries.

In California, then, the local air pollution-control district has primary responsibility for the administration of the control program. Rules and regulations consistent with State law are made by the local control board and enforced by the local control officer. Violators subject to criminal punishment are prosecuted by the local prosecuting attorney in the local courts. Requests for variances from the rules and appeals from decisions of the control officer are determined by the local hearing board.

It is recognized, of course, that any sound program of air-pollution control must be tailored to the individual program area under consideration. The size of the area, its population and industry, and the nature and extent of its pollution, are certainly pertinent factors. How much is spent on an air-pollution program depends of course on available funds. Moreover, if the program has effective regulations and controls, it matters little whether the enforcement officer is a member of the public safety, health, or building department of a city or county, or whether he is the head of an independent district agency. Specialists are of course a necessary adjunct of any effective air-pollution control program—scientists, chemists, and engineers are needed for research and development of control techniques.

Within local control programs, of course, there are also separate levels of responsibility. While one group may have responsibility for rulemaking, another may function as the enforcement branch; while one may have duties in the realm of hearing and deciding individual cases or problems, another may function in an advisory capacity.

The primary responsibility for the administration of an effective air-pollution control program rests upon local authorities in most cases, but if that local authority is too small in relation to the size of its problem, it will surely fail unless it receives cooperation from its neighbors or assistance from some superior governmental agency.

III. REGIONAL AND FEDERAL ACTION

Interstate Compacts

As it has been frequently stated, air pollution respects no political boundaries. State boundaries are no exception. In a negative fashion, the Constitution of the United States recognizes the inherent power of a sovereign State to contract with its neighbor for the common good, in article I, section 10, clause 3, as follows:

> **No State shall, without the Consent of Congress . . . enter into any agreement or Compact with another State. . . .**

The courts have held that this consent may be given by Congress after, as well as before the agreement between the States is made (*State* v. *Joslin*, 116 Kan. 615, 227 P. 543).

The framework is present then whereby States may agree, one with the other, on methods and programs for alleviating air pollution. Mutual problems in contiguous areas are subject to solution by such agreements. The sources of air pollution within a particular State may be ascertainable, but if the effects of contaminants in the atmosphere transcend the boundaries of a particular State, no solution is possible without (1) Federal control or (2) interstate compact.

Since few serious air-contamination problems can be met without law enforcement, it is clear that an adequate air-pollution control program for adjoining industrial areas in separate States must contemplate some form of regional control. Federal action may be impossible because of constitutional limitations (see infra). Two or more States may agree, however, on an adequate control program limited to their contiguous areas.

Constitutional Problems Involved in Federal Action

In considering any proposal of Federal action in the field of air pollution we are confronted with constitutional problems. Fundamentally, the Constitution endows the National Government with certain enumerated powers but reserves the rest to the States.

Although the control of air pollution is not to be found among the enumerated powers in explicit terms, neither is the protection of public health or the prevention of pollution of streams, and yet the Federal Government does exercise a substantial amount of control in these fields. These are, of course, but examples of Federal activity in what are normally considered State problems.

The commerce clause of the U.S. Constitution would be the most reasonable provision upon which to base the *control* aspects of a national program of air-pollution control.

The commerce clause provides:

> The Congress shall have Power . . . To regulate Commerce with foreign Nations, and among the several States . . . (Art. I, Sec. 8, U.S. Constitution.)

Essential to the use of the commerce power is that the subject of legislation or something closely related to it shall cross State lines. There is no doubt that polluted air may cross State lines. Whether it does so in most cases is highly speculative. We do know, however, that airborne products of many industries which contribute to air pollution are crossing State lines daily.

Just as Congress controls navigable streams, protects migratory birds, and regulates air navigation, it is likely that Congress has the legal power to prevent pollution of the national airspace. Congress has never attempted to exercise this power, and there appears to be no case law directly in point. However, there appears to be no logical distinction between pollution of a navigable stream of water and like pollution of an interstate stream of air.[2]

Suffice it to say that if the pollution of air increases as a menace to the public welfare, and if the States are unable to or fail to control it themselves, the Constitution of the United States is not apt to be an insurmountable barrier to Federal enactments in this field.

Essentially, then, police powers are the province of the State and Congress has no general power to enact police regulations within the territorial limits of a State (*United States* v. *Dewitt*, 9 L. Ed. 593; *Woods* v. *Carl*, Ark. 87 S. W. 621). However, in the exercise of powers granted to it by the Constitution, Congress may enact regulations which, if enacted by the States, would be considered police regulations.

Federal Action

Congress, of course, has acted to a limited extent already. By Public Law 159 (1955) for example, Congress authorized the Public Health Service to conduct research on the problems of pollution of the air. It expressly affirmed:

> The policy of Congress to preserve and protect the primary responsibilities and rights of States and local governments in controlling air pollution, to support and aid technical research to devise and develop methods of abating such pollution, and to provide Federal technical services and financial aid to State and local government, air pollution control agencies, and other public and private institutions in the formulation and execution of their air pollution abatement research program. • • •

Through appropriations of $8.5 million for the first 3 fiscal years, the Public Health Service has been enabled to carry out a research program that has already been of much assistance to State and local air-pollution authorities. In addition to research, the Federal program has included basic and advanced training of professional personnel from State and local governments, industry, and other institutions in the problems and techniques of air-pollution control. This training program includes courses at the Robert A. Taft Sanitary Engineering Center at Cincinnati, field orientation courses, and the preparation of manuals used in training other personnel. Courses of study at several universities throughout the Nation have been supported by grants from the Public Health Service in the field of study of atmospheric contaminants.

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[2] See 49 U.S.C. 176a; 49 U.S.C. 403; *United States* v. *Causby*, 328 U.S. 256, 266; 90 L. Ed. 1206; *Gardner* v. *Allegheny County*, 382 Pa. 88, 114 Atl. 2d 491.

It is of paramount importance that aggressive steps be taken by the Congress to assure a continuation without interruption of the splendid work now being achieved by the Public Health Service and the U.S. Surgeon General.

Recently a committee of Congress considered, and rejected, Federal legislation designed to control pollution of the air by vehicles engaged in interstate commerce. This was the so-called Schenck Bill (H.R. 9368). As pointed out earlier, Congress has primary responsibility for regulating commerce between the States, and no State may impose regulations which unduly burden interstate commerce. It was felt by the proponents of the bill that Federal responsibility was most appropriate in this field. As of this date, however, Congress has not seen fit to accept this responsibility, but one may predict that as both total contamination and technical knowledge increase, pressure for Federal regulation will likewise grow.

An outstanding example of public cooperation is presented in the ready acceptance by the 6 million people in Los Angeles County of the ban against the incineration of rubbish. The Board of Supervisors adopted a rule forbidding the burning of backyard incinerators on and after October 1, 1957. There was, of course, serious objection from the manufacturers of backyard incinerators. There was, however, a genuine readiness on the part of the entire community to make this additional sacrifice and undertake the more expensive collection of combustible rubbish in an effort to reduce the total amount of air pollution.

IV. A PLAN FOR THE FUTURE

Too often in the past we as a people have sent a boy on a man's errand. One may even speculate that the treasure we have wasted on various social and economic schemes might, if intelligently applied, have defeated polio decades earlier, or perhaps have already conquered cancer or heart disease.

Now we are in the infant stage of true air-pollution control. The time to act is now, and the place is here. Will we forcefully attack that problem in one coordinated effort, or are we to muddle along separately, each puny effort too little, too poor, and too late?

Let me outline a plan for the logical and effective assignment of responsibility among levels of government. I believe an implementation of such a plan is absolutely essential if we are to defeat air pollution before it smothers us. The plan is as follows:

The Federal Assignment

The Federal Government as representative of us all, and with first call upon tax revenues, is the logical agency to perform or finance research projects, special studies, project coordination, and information in those areas involving the general field of air contamination. As examples, the study of disaster such as the Donora episode of 1948, research in the effects of air contaminants on health, and studies of meteorology versus air pollution, can best be accomplished by one central agency, rather than by 49 States or 3,000 communities.

The Federal assignment should also include regulations, on the Federal level, of those sources which States cannot effectively control. This includes air contamination from vehicles and ships engaged in interstate commerce.

Perhaps the finest function that the Federal Government can perform is in the field of furnishing information. Many local control programs are essentially one-man organizations. They do not have either the time, equipment, or funds to carry on air monitoring, extensive laboratory analysis, or fuel studies. They cannot evaluate the economic effects which a proposed regulation will have. Without such information, the local control program may be limited to control of visible emissions. With the necessary knowledge at hand, the control officer can move firmly and with confidence.

The State Assignment

The responsibility of the State varies somewhat with its size and the nature of its air-pollution problem. Generally speaking, State responsibility includes research, development, control legislation, and enabling legislation. Some State research will be directed at conditions peculiar to its own territory. Some should be directed at supplementing Federal research. There will doubtless be some overlap here, but some duplication of research is obviously necessary and beneficial. I believe it can be safely concluded in any event that the field is too broad to worry, at this date, about oversaturation in research.

Government at the State level is also admirably equipped to perform developmental work on devices, fuels, processes, and similar concrete air-pollution preventives. Such work is too expensive for most local agencies to perform, and the Federal effort should not be diluted by encompassing the field of development.

Most States at present have existing legislation, constitutional provisions, or case law[3] which give cities and counties ample authority to deal with local air contamination. It is clearly the State's function to insure that every legal weapon is at the disposal of the local agency. This should include authority to employ the prohibitory regulation, a permit system, and the authority of local agencies to join together by contract or into a district of some type.

In some instances the State itself will find it convenient to enter into direct legislation and administration of the control program. However, local or regional agencies are far better equipped, in most instances, to engage in direct control than is the State form of government. In the case of local districts having police power to adopt reasonable rules and regulations, as the technology and research indicates the need for more strict regulation, such can be adopted within a comparatively short time. This is such an important point that it deserves an illustration. This fall in Los Angeles County it became apparent that steam-electric powerplants and refineries were burning vast amounts of residual fuel oil during the worst smog season of the year, despite the fact that natural gas was plentiful and available. A regulation was drafted and is being considered by our Air Pollution Control District to ban the pollutant-producing fuel.

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[3] See "Legal Support for Los Angeles County's Strict Air Pollution Control Program" by Harold W. Kennedy, county counsel, report submitted to the Board of Supervisors of the County of Los Angeles, September 1957.

By contrast, because the California Legislature meets in regular session only in alternate years (and is frequently overburdened at this time), in one case it took *3 years* to secure a minor administrative revision in the State law.

The Local Assignment

Cities, counties, and districts are the entities now bearing the largest burden in air-pollution control. It appears that despite Federal and State assistance, they will continue to do so. Local agencies are best equipped to assess the local situation, determine the most suitable method of control, adopt and carry out a permit system and adopt rules of conduct, and enforce the State law and local regulations.

It is very clear to those of us whose localities have crossed the "smog threshold" that the way must always be left open to allow cities and counties to tailor their control programs to the local need. By far the greatest danger to these vital programs is a State regulation which will occupy the field, and then dilute local programs by reducing control to the least common denominator. It is a fact of political life that strong legislation is almost always so changed in committee consideration that it will not be burdensome to the county or city having the smallest problem, rather than strengthened to aid that area in most serious danger. This must not happen in air-pollution control.

V. CONCLUSION

Levels of responsibility for the administration of air-pollution control programs are necessarily divided according to the type of activity involved, the size of the area, the particular topographical and meteorological situation, and the relative seriousness of the problem. With the development of atomic energy, whether for industrial purposes or for war, there are those who foresee the possibility that great quantities of airborne radioactive industrial wastes may cross whole continents and oceans. It is at once apparent that we may be rapidly approaching worldwide legal problems of air pollution.

Nevertheless, the city or county remains the enforcement level of responsibility in most areas throughout the Nation. States have either remained completely aloof or have passed enabling legislation or Statewide programs optional to the local bodies. The Federal Government has accepted limited responsibility for research and technical assistance to State and local agencies. As the problem of contamination of our atmosphere increases in intensity, it is obvious that the various levels of government must assume additional burdens in order to conquer the threat of the loss of our most basic natural resource—the air we breathe.

For America to win the war for cleaner air not only must the three levels of government—Federal, State, and local—fulfill their responsibilities but private industry, contributing to air contamination, must join the fight with all its skill and unlimited resources. This National Air Pollution Conference is the place to organize such a combat team.

Industries' Participation in Air Pollution Programs

Howard F. Roderick
Vice President
International Minerals & Chemical Corp.
Chicago, Ill.

Industry is in a new and better position to contribute to the national air-pollution-control effort as a result of new scientific findings.

After years of being regarded as the sole culprit in air pollution, industry is now found to be no more at fault than some of its principal accusers.

Open fires, auto engine fumes, public dumps, incinerators, plant pollen, and debris . . . in total . . . frequently contribute more to air pollution than what is usually ascribed to industry.

The point I make is this. Scientific evidence is beginning to clear the air . . . to clear it of the unfounded charges, the irresponsible statements, and the miscalculated guesses.

One of the major follies of some of our air-pollution efforts in the past has been the time spent in finding fault with each other on the basis of limited evidence. The big hope, and the one in which industry can play a major role, is massing a major scientific effort in appraising and evaluating the causes and effects of air pollution.

It will take a massive effort because, from the evidence mounting on all sides, it appears that what has been done so far is but a scratch on the surface. We are still in the pioneering stage.

Industry is reportedly spending $300 million annually to install and maintain air-pollution-control equipment on its plants. It is spending additional millions of dollars and man-hours on clean air research. It will spend millions more in forcing the air-pollution problem to yield an answer. When the answer is found, I believe it will result from advanced technology and improved research.

Under these circumstances, requiring an all-out effort on the part of our best talents to reach a solution, I fail to see where restrictive legislation and litigation can contribute to progress.

You have asked me to comment on industry's participation in air-pollution programs. As I see it, industry's participation must be as an equal partner with the community's government, health, and social groups in working toward a solution. Industry must be put in a position where it can contribute, and contribute something more than its neck.

In turn, it must recognize that it has a responsibility to the public to keep it informed of the work that is being done in the public interest. I think if an honest and diligent effort is made to keep the public informed, the reward will be public confidence and patience which permit the painstaking work of research to continue.

This has been the experience of the phosphate industry in Florida. It is a timely story in the sense that industry's efforts in that area are still going on. There has been marked progress there compared with what happened in the past. For these reasons and because it illustrates a pattern of industry-community cooperation, the experience is perhaps worth relating.

The phosphate mining area of Florida is in Polk County, in the central part of the State, about 20 miles east of Tampa. The principal occupations of the area, other than phosphate mining, are citrus fruit and cattle growing. It is the most productive citrus area of the State. It is also one of the world's richest phosphate areas. It produces more than 70 percent of the Nation's output and about 30 percent of the world supply.

Production of phosphate rock in Florida has increased in 10 years from 6 million tons of phosphate rock to more than 10 million tons . . . an increase of approximately 70 percent.

The phosphate rock is strip mined from 15 to 30 feet below the earth's surface and piped in a slurry to refineries. There it is dried and processed and shipped out in various forms, principally as fertilizer. In the drying and handling, considerable dust is raised which is collected by cyclone collectors, precipitators, and bag collectors.

A more recent development in the area is the production of phosphate chemicals from processed phosphate rock. Triple superphosphate, a highly concentrated fertilizer, is one of the chemical products. Prior to 1943, there were only one or two producers of triple superphosphate in the area. Now there are nine. In that relatively short period of time, production of triple superphosphate has increased to the point where Florida now supplies more than 80 percent of the Nation's production of triple superphosphate.

This growth of production was a reflection of what was happening as a general pattern all over the country. The population was growing and Florida is one of the fastest growing States in the Nation. Central Florida, the area we are talking about, has had a population growth equal to or better than the State's average.

As production grew and population in the phosphate area grew, so did complaints about air pollution. They came from citrus growers, flower growers, and cattle raisers. The basis for the complaints was alleged fluorine damage to crops and fluorosis in cattle. There was a time 2 years ago when you rarely picked up an edition of the newspapers in the area when someone wasn't directing a charge against the phosphate companies.

Finally, in June 1955, the Florida State Legislature created a Joint Committee on Air Pollution which conducted five hearings, several of them public hearings in Polk County. The result was passage of an air-pollution law, by the State legislature in 1957, creating an Air Pollution Commission. The commission has nine members, two of them representing the industry.

By this time, several damage suits were filed against the phosphate companies.

What were they doing all this time to handle the problem?

Speaking for my own company, International Minerals and Chemical Corp., the largest operator in the field, we had been conducting effluent control measures from the start-up of our plants. We had introduced improved equipment to the extent that by next July we will have in excess of $3 million worth of the most modern waste-control equipment in operation. About a million of this will be spent between now and July on our triple superphosphate plant.

I would estimate that the phosphate industry in Polk County has about $6 million invested in effluent control equipment.

In addition, it costs our company nearly a quarter of a million dollars annually to operate its control program.

In its research laboratory, International Minerals and Chemical Corp. undertook leaf sampling and evaluation studies to determine the cause and nature of alleged crop damage in an effort to determine to what extent the phosphate companies might be responsible. In the next 3 years, International spent nearly $300,000 on these studies.

From close observation, or actual experience with air-pollution research work, you begin to appreciate the tedious, tireless effort it takes. In one period of 90 days, our researchers, conducting leaf sampling, covered an 800-square-mile area.

We didn't know then, but we do now, that this was pioneer work on air-pollution damage to citrus crops we were conducting.

We have since come to appreciate how little is known about air-pollution damage, the levels of toxicity, the effects of temperature, wind, soil, rainfall, and a dozen other variables.

We have learned that the findings on air pollution in one area do not necessarily apply to another. And that much research money and effort must be expended in providing a control base on which to judge findings or samplings.

If the Florida phosphate industry was guilty of anything up to this point, it was failure in two respects.

1. Failure to recognize that the public regarded the alleged air pollution as an industry matter. No matter how good any one company's control program was, the complaints were lodged against the phosphate companies in total. Failing to recognize this, the companies did not organize as an industry group.

2. The second failure at this time was failure to keep the public informed of the work the industry had done on effluent control. If the phosphate companies had taken the public into their confidence they could have gained the public understanding and patience they needed to carry on their research efforts.

I am pleased to report that both steps have since been accomplished by an organized industry group with significant results.

A Florida phosphate producers committee was formed initially to represent the six participating members before the hearings of the State legislative committee. It has since become a permanent organization with a twofold program covering research and public relations.

Resources Research, Inc., of Washington, has been retained to conduct expert and impartial scientific research into the causes and effects of alleged air pollution in Polk County. Dr. Louis McCabe, president of the organization, who has had extensive experience as the first director of the Los Angeles Control District and in Federal Government control work, is directing the research progrm. A new field laboratory has been established in Polk County, Fla., and is presently conducting extensive field studies.

It is too soon to report any major developments in the research effort because of the time requirements which I mentioned earlier.

A respected local public relations firm in Polk County has been retained to counsel and direct the Florida Producers' public relations program.

This program, in the last 6 months, has gained better understanding for the phosphate industry's problems than has ever existed before in that area. Our industry recognizes that it is receiving an expression of public confidence and good will, which it must respect.

The first step undertaken by public relations was to announce the Florida producers' twofold program at a meeting where newsmen could meet and question Dr. McCabe. This story received prominent attention in the press.

Since then, Dr. McCabe has appeared on planned programs before local service groups to describe this work. These appearances have served as devices for reporting to the public additional aspects of his program.

Meanwhile, the industry continues to gain greater public understanding and appreciation as a result of stories sketching its economic importance to the State and community.

While the final outcome of this effort is yet to be judged, I think the results so far are significant enough to commend them to your attention.

In summary, let me say that a soundly directed scientific search for the real facts on air pollution will attract industry's wholehearted participation. Industry has two impelling reasons to contribute to such a program.

1. The increasing need to demonstrate openly the regard it has for its responsibilities in this area, and
2. Its profit requirement.

Practically everything that is carried off in the air stream represents an economic loss to industry.

For its part industry needs to organize its pollution research and control efforts, which are costing millions of dollars, so that they become a massive move toward a permanent solution. Having taken this step, industry needs to inform people of its program. When it does, it gains an understanding ally.

How Can Community Sentiment on Air-Pollution Problems Be Determined and Community Action Be Initiated?

Donald C. Wagner
Managing Director
City of Philadelphia, Pa.

During the past 6 years, Philadelphia has been engaged in developing a practical program of air-pollution control that would be sensitive, on the one hand, to the health needs of people and, on the other, would not impede the economic growth and development of the city.

This twofold objective is, of course, fully acceptable to the general public, which is primarily interested in breathing comfortably. And it is also acceptable to industry, since our emphasis is upon control solutions that do not threaten the economic security of our local industrial concerns but which still correct the basic problem.

The staff of the air-pollution-control section of the department of public health recognized very early in the development of this program that the only way to tap community sentiment with respect to air-pollution-control programs is to involve the community in the real and basic policy decisions that ultimately result in programs. This is not, to be sure, a new concept in the annals of government administration, but it is one which some administrators may still view with reservation.

This hesitancy may be illustrated by some of the comments we have received in discussing citizen participation. There are those who fear that control of the program will be surrendered to the citizen group, and they have asked very pertinent questions concerning the extent of possible political influence on the department's activity.

Others have wondered about the possibility of interference in the development of programs and have questioned the role of industrial interests in such decisionmaking; they ask what happens when departmental personnel do not agree with the decisions of the advisory group.

We have often been asked to explain the advantages of this technique, and we find that those who raise these questions generally assume that a qualified public health administrator, supported by well-trained technical staff, is in a far better position to plan within the Department, and perhaps should not seek the participation of lay groups in the planning process.

Our experience has convinced us, however, that lay participation in planning air-pollution-control programs is healthy and sound, and one of the best ways to explore and use community sentiment.

Some historical background may help to make the process clear.

The roots of our program go back to 1949, when the American Public Health Association surveyed Philadelphia's public health needs and resources. Shortly thereafter, local citizen support for an improved municipal administrative structure resulted in the adoption by the electorate of the Philadelphia Home Rule Charter, a document that prepared the way for a comprehensive reorganization of the local department of public health.

In 1952, a new commissioner of health, trained in public health and experienced in government administration, was appointed, and the following year witnessed the appointment, through open competitive civil service examination, of a trained and experienced public health engineer assigned to direct the sanitation functions of the department.

The new home-rule charter of the city directed the air-pollution-control board, an eight-man advisory body to the department, to prepare a comprehensive code for submission to the city council. This was required, it was believed, because the legislative base for public health law in Philadelphia rested on a variety of miscellaneous ordinances dating back to the early years of this century and beyond.

Out of this mandate to review, consolidate, and improve the city's ordinances grew what we now call the air-pollution-control code, which was passed by the city council in 1954, and to which, later, were appended specific regulations of the air-pollution-control board.

In Philadelphia, community participation in the air-pollution-control program begins, I believe, with the drafting of the air-pollution-control code and its regulations. The code itself was subjected to thorough review by the community in the course of its adoption.

Both industry and the lay public had a role in this review, with primary assistance coming from the chamber of commerce and the community's many civic organizations. The regulations, which specifically implement the general code, were also the product of active community participation, often developed by actual negotiation with representatives of the industrial groups affected by them.

We have found that, if there is adequate community representation during the drafting of our laws, many difficulties may be avoided. The use of such representation while preparing the basic draft provides the administrator with an important means of educating key members of the community, while at the same time giving a full sense of what the citizen expects from the proposed legislation. There is no doubt that true representation leads to an adequate accommodation of conflicting points of view. This means that, when the regulations are brought forward for the necessary public hearing before city council, members of the community, rather than only the administrator and the legislator, will be defending the validity, fairness, and reasonableness of the final draft.

One or two examples might serve to make this process clear.

On January 1, 1958, open burning on Philadelphia dumps and on auto-wrecking yards came to an end. The city recognized that the end of open burning made it necessary to have regulations governing the conduct of sanitary land fills, which would replace open burning as a method of refuse disposal. Therefore, at a time when the city was still involved in a rather lengthy legal battle over the open-burning ban, an advisory committee began writing regulations for sanitary land fill.

The committee included a segment of the industry most seriously affected—among others, the operator of a dump and one of the attorneys who was at that time contesting the open-burning ban before various administrative boards and in the courts. One might suppose, under such circumstances, that a reasonable regulation would not be forthcoming. Indeed, one would expect the affected industry, through its representation, to wage a battle of delay. Such was not the case. Other representatives on the subcommittee included a professor in civil engineering from a local college, a person experienced in city planning, the engineer in charge of our municipal incinerator, a member of the chamber of commerce who had experience in government administration, and two informed members of the community who, due to their employment, had knowledge of the advantages and disadvantages of various methods of refuse disposal.

Although having individual points of view, some of them strongly antithetical to each other, the committee was able to arrive at a set of regulations which were in the public interest.

For some reason, which perhaps a social scientist could better analyze than I, the process of group thinking appears to differ substantially from that of the individuals who make up the group. Apparently each individual is willing, or else is forced by the dynamics of the situation, to abandon just a little of his personal interest in the search for a solution that is satisfactory to all parties. In any event, we have found that the technique works. When these regulations had their public hearings, they met with no resistance.

We had equal success when we drafted regulations governing the operation of rendering plants. Staff had found that the control of odors from these plants involves a great deal more than simply placing devices in the effluent streams from the cookers. Many of the odor problems stem directly from general insanitary conditions in the whole operation. For this reason, the health department decided that the approach to the control of odors in the rendering plant industry must be broad and comprehensive.

The first step was to draft what the technical staff considered rather ideal regulations. These were reviewed by an advisory committee comprising some 15 persons drawn from all walks of community life, including industry, commerce, and education. A subcommittee was appointed, and to this body were named an owner of a rendering plant and an attorney representing that industry. This committee also included an industrial physician, an official of the union representing workers in the rendering industry, and a veterinarian whose point of view was consistent with that of the general public.

This subcommittee reviewed the draft regulations, recommended changes, and made additions; after which the resulting documents went back to the parent committee for final consideration. This accomplished, the regulations were given a final inspection by the board of health, the department's top citizen advisory group, and by the air-pollution-control board.

This thorough, if somewhat prolonged, process of review resulted in a set of regulations that satisfied both staff and industry, and passed through public hearings without contest.

We have found that citizen advisory bodies not only serve as excellent sounding boards to gage public opinion, but they are a mechanism for making available to city government the best brains in the community. Ordinarily, such talent could not be purchased.

But we have also found that if an air-pollution-control agency expects to have the assistance of industry in attaining the community's objective, then the department must be willing to reciprocate. In Philadelphia, we encourage industry to discuss problems with us. Through mutual understanding, many satisfactory solutions are evolved. Because of its breadth of contact and experience, the official agency is often able to point out engineering pitfalls to be avoided, and can also indicate methods of control that have been found successful in the past. In other words, the air-pollution-control section serves as a kind of consultant to industry. And, of course, behind this consultative role lies the implicit possibility of enforcement.

The principle underlying this program is that the prevention of air pollution avoids the need for enforcement action later. To achieve this objective, we have provided that the plans of proposed installations of fuel burning and processing equipment, as well as air-cleaning devices, are required to be approved by the air-pollution-control section before permits will be issued to proceed with installation and construction. Compliance inspections are made to see that the completed work conforms with the permit.

I suppose in summary one might say that in Philadelphia we go further than merely determining community sentiment on air-pollution problems. We actually incorporate the citizens' point of view into the basic legislation. But it would be naive to think that the resulting law is the product of public opinion alone. It is obviously much more than that: it is the sum of public opinion and technical acumen, the tempering of science by the practical demands of our economy.

The step from determining the community point of view to the initiation of program is, under these conditions, relatively comfortable. The industries affected by the legislation have actually participated in its drafting; if they are not enthusiastic about the results, they are at least well informed; they have grown up, as it were, within the legislative structure to which they will later be asked to conform. The individual and sometimes tense attitudes they have brought to the advisory committee meetings have been softened by the process of group discussion. This is, to my mind, arbitration before, rather than after, the development of conflict.

Our experience with the growth of the air-pollution-control program in Philadelphia seems to me to bear ample testimony to the success of this method. In the past 6 years, we have eliminated open burning on dumps, initiated a multimillion-dollar incinerator program, seen the end of coal-burning engines and black industrial stacks, and guided industry in making major control installations that have, in quite measurable ways, improved the community's air.

What may be still more important, we have developed working relationships between government and industry that will, I believe, have continuing ramifications throughout the whole fabric of community development. Any large city is, after all, deeply concerned with its productive resources.

This method of community participation in planning seems to us to be one of the best techniques for striking the necessary balance between the requirements of these resources and the health and well-being of the people.

Achieving Balance in Air-Pollution Activities Through Education, Voluntary Action, Legal Enforcement, and Budget

Dr. Leonard Greenburg
Commissioner
City Department of Air Pollution Control
New York City, N.Y.

The task of the official in charge of the activities of the official air-pollution-control agency is by no means a simple one. On the one hand, his activities are governed by the statutes, codes, and regulations under which he is compelled to operate and, on the other hand, he is often presented with a variety of problems having widely different modifying factors which interfere with the routine application of the laws and codes and hence call for flexibility in the administration of the program.

These facts have an important bearing on the legal foundation and administrative pattern of the control agency. It is not the purpose of this brief presentation to discuss this aspect of the organization and administration of the air-pollution-control agency. Suffice it to say that recognition should be given to the need for flexibility in the administrative and functional design of the official agency.

The flexibility in the conduct of the official agency resides in the hands of the agency's director. This calls for judgment, based on a sound analysis of the problem at hand and skill in the presentation of problems to those concerned.

For many years, sources of air pollution have been in existence in most, if not all, of our older and many of our younger cities and also, in some instances, rural areas. Each day our communities are building new homes, office buildings, factories, and industries. Not alone are these increasing the number of potential sources of air pollution, but new factories and industries often mean new and different kinds of pollution.

The control of the community air-pollution problem may, therefore, be simply stated as:

1. The correction and/or elimination of present sources of air pollution.
2. The prevention of the building of new sources of air pollution.

This means of accomplishing control in the two areas cited ideally lies in a combination of legal enforcement, voluntary action, and education. Indeed, it is more satisfactory to say education and voluntary action, backed up by legal enforcement.

Let us for a moment consider the problem with reference to existing sources of pollution. It is often difficult for the owner or manager of a building or factory, which has been in existence for some time and which only recently is found to be in violation of new regulations, to understand why he should be suddenly called upon to make changes in the physical equipment of his installation. To make such changes in the physical equipment of his installation is often expensive and sometimes difficult, due to space and other limitations. A lack of understanding of the problem and the significance of the importance of air pollution to the community as a whole often constitute the background of the thinking of the property owner when he is confronted with making a decision as to what he should do in reply to a request for control action.

As a rule, it is very difficult to change the habits and activities of people, and to change their mental approach to problems is still more difficult and time consuming. As evidence of this, we merely need to reflect on the enormous sums of money and effort spent in advertising the common products in everyday use.

This fundamental fact must be borne in mind by control officials. The resistance to action must be evaluated objectively and should, insofar as possible, be overcome by a campaign of education.

The educational program of the agency should be broad in scope—covering all ages of population from schoolchildren to adults—from private citizens to the owners of large establishments. It should carry the message that all inhabitants of the area may be deprived of one of the important needs of the human mechanism—pure air; that all persons may be the victims of what polluted air does and that the "common good" demands that each must do his part in refraining from polluting the atmosphere we all require for life. From here it is a short step but, nevertheless, often a difficult one, to the need for public-spirited action, to desire to do something about it, and to expend the funds necessary for such action. In some instances the course of action outlined here will move quite easily from one step to the next and a solution will be achieved in a minimum of time; in other cases difficulty may be experienced. There is one fact which always must be borne in mind—at no time can the agency proceed without the objective evidence which demonstrates the need for correction. With such evidence at hand, a groundwork of education, and the exercise of the art of gentle persuasion, success can practically always be achieved by voluntary action.

Voluntary action is then the result of the request for action by the agency, built on a foundation of education of the public. Brief mention has been made of the role of education. The details of the educational program cannot be elaborated here, for this is not the time and place for such a discussion. But reference should be made to the role of public relations. The agency is supported by tax funds—and the public, which pays the bill, is entitled to know what the agency is doing, how it is attempting its job, and why. Remember, a public relations man is not employed to make wrong seem right any more than he can make black appear white. It is the duty of the director to devise an objective and reasonable program for action, and it is the duty of the public relations officer to inform the people about the program and to demonstrate again and again the reasonability built into it.

In this connection, I think that one of the best expressions of what good public relations is was made by Mr. K. T. Keller, formerly of the Chrysler Corp., who said last year:

> You can't hire people to give you good press * * * This idea that public relations men are publicity men and can write you into some kind of position is entirely erroneous * * * they can get stories in, but when the facts don't back them up you are worse off than if you had never put them in.
>
> Public relations start with what you do and your attitude toward what you do, not with what you bring somebody in to write what you think would be favorable for the company * * * To me, the good public relations man should sit in every board meeting * * * and he should represent the public and not be an employee. He is the kind of fellow to say: "Listen, you boys are going to do something here that is bad for public relations. You better do this another way, not a scheming way."

It is a great aid in promoting the program to arrange in some manner to have the public accept wide participation in the agency's efforts. One excellent way of achieving this is by encouraging the making of complaints by the public generally. This may be done by telephone or by mail. In every such case, the complaint should be followed by an investigation of the alleged source and in every possible case by having the inspector call personally on the complainant. Simply stated, the procedure should be as rapid and as effective as possible.

In contacts with complainants, it is also important to stress the fact that, just as everyone suffers from air pollution at some time or other, air pollution is caused by the citizens and, therefore, each of us must examine our own equipment, if we own or control such equipment, and make certain that it is not a source of air pollution.

Through the use of the mass media and the publication of educational pamphlets, it can be demonstrated to the public that air pollution results in economic loss and is a health hazard and that there is something each citizen can do to help reduce air pollution. Pamphlets designed to demonstrate how to reduce air pollution from automotive vehicles, oil burners, apartment-house incinerators, and the burning of leaves have proven very effective in the New York City program.

Earlier, mention was made of the need for the building of new air-pollution control in new installations. In this area of the agency's activity it is possible to achieve excellent results by the application of proven engineering design and standards into new equipment. In order to do this, the educational program plays an important role and the application of a well-designed educational program and realistic engineering standards seldom fails to lead to installations which do not become sources of pollution.

There is little doubt that the educational program yields large results in terms of accomplishments at a minimum cost. Legal action in enforcement is far more costly and time consuming. But it is essential that the legal mechanisms be readily at hand and, in fact, used from time to time. In order to reduce the cost of such approaches, the process should be simplified as much as possible. Office hearings can do much to aid in achieving the desired results.

The cost of the operation of the control agency may vary from a minimum of 5 cents per capita to $1 or more per capita, depending, of course, on the size of the city, the area to be covered, and the severity of the problem. Most American cities today are pressed hard for funds—inflation has played hob with municipal budgets. It is, therefore, extremely important that the control agency do everything in its power to see to it that its program of action is designed to accomplish results with a minimum of expenditure. Programs of action must always be devised with tight budgets in mind. This calls for a constant review of the balance which the control agency is maintaining between its educational program, its efforts on voluntary action, and its legal enforcement. For, if the control agency can produce the results desired by the taxpayers, there is little doubt in my mind that adequate budgets will be available to it.

I think it is clear that the cooperation of the citizens is vital if the control agency is to make progress in the fight for cleaner air. By the same token, it is, of course, necessary, in order to maintain such public cooperation, that the control agency show results and show them constantly.

It is difficult to envisage a time in our modern civilization when there will be no air pollution at all. But it is not difficult to see a time when air pollution will be materially reduced. A balanced program of action, using all weapons at the command of the control agency, is the only way to achieve this success. And, in the long run, the cooperation of every citizen will spell victory or defeat in the fight against air pollution.

The Proper Role of Planning and Zoning in Air Pollution Control

Dr. Richard May, Jr.
Raymond and May Associates
White Plains, N.Y.

It is not without temerity that I approach the subject of the relationship between the professions of planning and air-pollution control, since the investigations and study that I have given to this subject, in the course of developing zoning regulations embodying performance standards for air pollution for several communities, have indicated to me that there is a fundamental difference in the way the two professions must approach the problem. To put it simply, the planner approaches this problem like any other problem he deals with—that is from the point of view of the land, how it may be used, or what activities may be permitted in a particular location in terms of their effect on adjacent land and the development of the entire community. You, who deal with air pollution, must of necessity, of course, deal with the atmosphere; and since the atmosphere has no walls, streets, or other barriers, and is fluid or moving, your problem is very different from that of the planner who deals with something which is fixed at least in its location for a period of time In spite of these differences in approach our two professions have a common problem, and to deal with it we must learn to understand each other's aims and methods. By working at this problem in a cooperative way I feel that we can develop workable solutions even though they may involve some adjustment in methods on both our parts.

Let me make clear at the outset that although the planner knows little or nothing, from the technical standpoint, regarding the control of air pollution, he is just as interested as this profession in the reduction of air pollution and the attainment of a clear atmosphere in our metropolitan areas.

One might say that planning in terms of land-use control or zoning has passed through two distinct periods of development, and will, in the not too distant future, perhaps enter a third phase. These three phases might be summarized as follows:

1. The early period starting in 1916 with the adoption of the first zoning ordinance in New York City, which might be characterized as a period of "control by location only." That is, that general types of new construction could be separated from one another on the land; residences here, commercial uses there, and industrial uses over here.
2. The period we are now in might be called the "period of possible control" of the activities or of the possible objectionable elements which might be emitted by any particular use, in addition to mere control over location which was possible during the first period.
3. The period which we may enter in the not too distant future in which controls over location will recede in importance and be gradually replaced by controls over activity.

Let us discuss each of these phases in detail. The first zoning ordinances in the country were enacted during a period in which industrial activities were generally unsightly and dirty in many respects. In fact it was because of these conditions that zoning was conceived, principally as a method of bringing about the separation of industry from residential areas. This was the era of soft coal as the only fuel for heat and power. Gas, oil, and electricity were only beginning to emerge in terms of large-scale utilization. Since the control of emissions of air pollutants was neither technologically nor economically feasible these first controls were confined to that of location.

However, even in this early period, air-pollution factors were taken into consideration indirectly in early zoning ordinances. Uses or activities which were permitted in the various districts were specifically listed, and a study of the listings of the types of industries which were permitted in the light, medium, or heavy industrial districts in some of our earliest zoning ordinances clearly indicates a concern regarding potential air pollution. Only in the heaviest industrial districts could you have dyeworks, fertilizer mixing plants, chemical plants, steampower generating plants, sugar refineries, blast furnaces, distillation of bones, fat rendering, grease, lard or tallow manufacturing, etc. Uses confined to such areas involved dangers, excessive noise or vibration, odors, and other air pollutants. In many communities these heavier types of industries were completely excluded.

Although the characteristics of industries in terms of the relative amounts of objectionable elements, such as the above, which could be expected, was a strong factor in land planning and zoning, it was not, and still is not, the only factor affecting or requiring the segregation of land uses. There are other basic factors affecting land planning, such as for example the need by industry for level sites near transportation facilities and in locations near other industrial activities. Commercial uses are generally located at the focus of transportation routes and highways so as to be easily accessible from a number of directions. Sites sought for residential use are generally on high land with natural advantages and good environmental surroundings such as parks and open spaces.

To summarize, then, the period from which we are emerging is one in which the problem of air pollution and other objectionable elements such as noise were recognized, since they were serious and widespread due to the previous lack of any controls, as well as the lack of knowledge of how to control or limit the amount of emission of such elements. Yet there was recognition of the problem and an attempt to deal with it by segregating or zoning general types of activities into different areas of the community.

We now live in a period in which controls over the emission of objectionable elements have become both economically and technologically feasible. Although we have remaining with us a great many old structures, antiquated heating plants and industrial processing equipment, especially in the older parts of our cities, the rate of capital replacement and new industrial construction is very high. In order to meet competition, and because in many cases capital has become cheaper than labor, many plants are replacing their equipment and machinery and in addition are moving to new sites in outlying locations where horizontal operations are feasible and where they can provide ample parking for their employees.

The problem is how best to regulate new construction and new installations and also the vast number of older establishments which remain with us. Incidentally many of these older establishments are what we call nonconforming uses. That is, they are located in residential or other districts in which they are inappropriate and it would be better for all in the long run if their adverse environmental influences could be quickly minimized, or better still, if they could be encouraged to move to more appropriate locations.

This variety of conditions seems to point up the fact that there is not just one air-pollution problem even though there is one universal atmosphere—but there are a number of complex and different problems which unfortunately require a complex solution.

The planning profession has found that in practice the old method of merely listing permitted industries or activities by zoning district is no longer valid or fair because of the new techniques and equipment that have been developed, by your profession for one, in controlling the emission of objectionable elements. In view of the expanding possibility of controls we feel that it is essential to develop regulations which vary by area or district and which are based upon the peculiar needs and the land use pattern characteristics of each area within the city. We also feel that it will be possible to raise the general level of atmospheric conditions more quickly by imposing more stringent standards on *new* development or new construction than one can successfully impose upon existing industries or activities.

This spatial and temporal concept is at variance with the general type of regulations used in the air-pollution-control field under which, as I understand it, there is one common or universal regulation for an entire municipality with possible variations by use, such as for example, a different regulation or standard for an apartment house, an office building, or an industrial use. In proposing variations by district the planner makes an assumption that space or distance is a factor which minimizes pollution impact. I believe I am right in saying that although pollutants, once in the air, can travel great distances, there is a factor of diffusion, and the further one gets from the source of pollution the less, in most cases, the impact or effect will be found to exist. We therefore feel it is possible and thus necessary to require higher standards in the vicinity of residential areas and that a relaxation of standards is possible as we move away from these areas. One important effect of this type of regulation, as opposed to one based on use, is that it would act in a more stringent way to reduce the adverse effects of nonconforming industrial uses located within residential areas, which are a great problem in many parts of our cities.

It would seem therefore that if we are to achieve our common aim of improved atmospheric conditions, an ultimately higher level of cleanliness can be achieved by the imposition of stricter standards for new construction and also for all establishments within and near such critical areas as residential neighborhoods and retail or office centers which require more protection.

With this in mind we have in many new zoning ordinances proposed industrial performance standards for new construction, and also standards which vary by district or location within the city. These new ordinances have brought to a head the problem of how to integrate the functions of zoning and air-pollution control. Although it may seem simpler to enforce one standard in a community, there are, as you know better than I, difficulties in arriving at a single standard which is neither so strict that it cannot be rigidly enforced with respect to some heavier industries or air-pollution sources, or which, on the other hand, is so lax that it cannot act to reduce emissions from a vast number of pollution sources such as apartment houses, commercial buildings, and light manufacturing plants. The answer to our mind lies in standards which vary as to new construction vs. existing uses and also by area, complex as these may have to be. The specific provisions or variations in such regulations between new construction and existing establishments are certainly matters which are beyond our profession and must be worked out by the air-pollution-control engineer. However, in the matter of variations in regulations, by area, we feel that the planners have a necessary function, although essentially these regulations must be developed in a joint or cooperative way between us. We feel that it is essential that planning considerations enter into area distinctions in regulations because we are dealing in our cities, not with static land use patterns as we find them today, but with evolving new patterns and changing functions within the city, which the planner is deeply concerned with.

The administrative machinery needed to develop this joint action should not present any serious problems. Both fields have developed methods and spheres of controls which can complement each other. Full advantage should be taken of the normal zoning enforcement machinery of building permits and certificates of occupancy, as well as air-pollution enforcement procedures which allow for administrative action in connection with any use at any time. To my mind the administrative enforcement of all air-pollution regulations, including the granting of certificates of compliance on all building permits and certificates of occupancy, should be the province of the air-pollution control agency once the regulations have been promulgated.

What I have proposed above is an approach to dealing with the problems that we face today. This is, as I stated above, a period which is characterized by great movements of industry and changes in industrial locations—and changes in fact within the entire complex of uses within our metropolitan areas—and an emerging science of control over the emission of objectionable elements. What of the future? Some day when the level of performance has been sufficiently improved it may be possible to have a single standard for all uses in all areas. Perhaps by that time planning factors will no longer be of import in the field of air pollution control. We may not even need many of the zoning districts as we know them today. I don't feel that we will be able to do without controls over population density or variations by district in the bulk of buildings, but perhaps we will be able to do away with many of our use regulations as we know them today. We may still be dealing with many prejudices which require basic use distinctions by specific lists, and I doubt whether we will be able to eliminate or sufficiently minimize the traffic impact which industries and commercial activities have as long as they continue to attract people in sufficiently large numbers. However, automation may even minimize this factor. But when this day arrives, if it ever does, most zoning regulations will be in the form of performance standards administered by agencies dealing with noise, air pollution, radiation, etc., and your profession will no longer have the problem of having to listen to a planner present his problems at such great length as I have today.

Solving Interstate Air Pollution Problems

Walter S. Cooper
General Counsel, Interstate Sanitation Commission
New York City, N.Y.

Any discussion of interstate air-pollution problems must, of necessity, entail a consideration of statutory efforts to control air pollution at its source before it becomes interstate in nature.

Air pollution has existed in the form of smoke and other byproducts of combustion ever since man learned to make fire—and it probably existed even before that in the natural transportation of pollen.

Historically, however, the antismoke regulations of England, adopted in the year 1273, in the reign of Edward I, can be regarded as the first organized endeavor to abate air pollution by statutory enactment. In the United States the smoke problem in many American cities in the latter half of the 19th century was sufficiently serious to result in the enactment of smoke-control ordinances, and the first ordinance giving specific authority to local government to regulate smoke discharge was adopted by Chicago in April 1881. Cincinnati adopted a smoke ordinance in November 1881, and St. Louis in 1893. By 1913, 23 of 28 cities with more than 200,000 population had smoke-abatement programs.[1]

A study made in 1955 estimated that in the United States there were 9,500 communities which had local air-pollution problems, and of these 2,050 had specific legislation concerning air pollution.[2]

Today we have gone beyond the theory that only smoke is an air pollutant, and we know that the sources of air pollution are many and varied and the emissions from such sources are even more varied.

A composite definition of "air pollution" as set forth in statewide and municipal air-pollution-control statutes states it to be the presence in the outdoor atmosphere of substances or one or more contaminants in quantities or concentration and of a duration as to cause any discomfort to a substantial number of inhabitants of a district or which are injurious to public health, or to human, plant, or animal life or to property, or which unreasonably interfere with the reasonable, comfortable enjoyment of life and property throughout the State or throughout such territories or areas of the State as shall be affected thereby.

Air contaminants are described as solids, liquids, gases, dust, fumes, mist, odors, smoke, vapor, pollen, charred paper, carbon, noxious or obnoxious acids, fumes, oxides, particulate matter, burning embers, sparks, cinders, soot, including their radioactive fractions or counterparts, or any combinations thereof.

It is readily apparent that such State and municipal ordinances and regulations were adopted because of conditions created by the tremendous industrial growth in our country and the rapid population growth in our larger cities.

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[1] A review and appraisal of air-pollution legislation in the United States, by Samuel M. Rogers, June 4, 1957, for the golden jubilee meeting of the APCA, St. Louis, Mo.

[2] 8 Baylor Law Review 249 (1956), citing report of Arthur C. Stern, 1955.

By the late 1930's and early 1940's it became increasingly evident that air pollution did not respect political boundaries. The enactment of statutes, rules, regulations, and codes by a particular metropolis are of no avail if the air contaminants of a neighboring community, without proper regulations, propelled by the vagaries of wind and air currents, or confined by topographical and meteorological conditions, are deployed over a regulated community, and accordingly it was recognized more and more that the control and abatement of air pollution was not a local problem, but one which called for a statewide regulation.

Attempts have been made in the legislatures of a number of States to enact statewide air-pollution-control legislation, but up to this time only 9 of our 49 States have an air-pollution-control statute, and these are of various degrees of statewide application.

In 1947, the State of California introduced the first measure toward statewide control of air pollution.[3] In 1952, Kentucky enacted air-pollution-control legislation;[4] in 1954, the States of New Jersey[5] and Massachusetts[6] enacted statewide air-pollution-control statutes; Oregon enacted a statewide statute in 1956,[7] and in 1957 the States of Washington,[8] Delaware,[9] Florida,[10] and New York[11] enacted statewide air-pollution-control legislation.

Examination of these statutes, however, discloses that the California, Washington, and Kentucky statutes provide for voluntary programs; that is, the statutes authorize the creation of air-pollution-control districts, contiguous with county boundaries, on local option. Several such air-pollution-control districts have been created in California, but even there, as recently as February of this year, Los Angeles County supervisors complained that other southern California counties were dragging their feet on air-pollution control and waiting for Los Angeles County taxpayers to finance the battle against smog, much of which, they claim, emanates from the surrounding counties where nothing is being done to control air-pollution sources.

The statutes of New Jersey and Florida are almost identical. A statewide air-pollution-control body is created which is, primarily, a legislative body for promulgation of codes and ordinances, and the State Board of Health is the enforcement body. The New Jersey statute has been supplemented by some codes and regulations which are being enforced in various parts of the State. The Florida Air Pollution Control Commission has been considering proposed regulations, but I do not believe any regulations as yet have been promulgated. Notable in the Florida statute is the exclusion from the definition of "air pollution" of the smoke effluent from pulp or paper mills equipped with and operating electrostatic precipitators or other mechanical devices whereby not less than 90 percent of the solids of such smoke are removed therefrom.

The Massachusetts statute leaves air-pollution abatement and control with local boards of health, but reserves to the State board of health the power to direct air-pollution abatement in any area on the complaint of an adjoining area or community.

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[3] Ch. 632, Laws of California, 1947.
[4] Ch. 53, Laws of Kentucky, 1952.
[5] Ch. 212, Laws of New Jersey, 1954.
[6] Ch. 672, Laws of Massachusetts, 1954.
[7] Oregon Revised Statutes, sec. 449.705 et seq., of 1956.
[8] Senate bill No. 160, 35th sess., Washington Legislature, 1957.
[9] Ch. 152, Laws of Delaware, 1957.
[10] Ch. 57-369, Laws of Florida, 1957.
[11] Ch. 931, Laws of New York, 1957.

Under the Oregon statute, codes, ordinances, and regulations of statewide application were adopted in December 1956; the Delaware statute is almost a copy of the Oregon statute, and late in 1957 the Delaware Air Pollution Authority commenced the promulgation of rules and regulations to supplement its statute.

The New York State statute, which created an air-pollution-control board within the State health department, provides that no codes, rules, or regulations promulgated by the air-pollution-control board shall become effective until July 1, 1959. The board, under the New York statute, is charged with the duty and responsibility, among others, of preparing and developing a general comprehensive plan for control and abatement of existing or new air pollution; of encouraging voluntary cooperation by all persons; of encouraging the formulation and execution of plans by cooperative groups or associations of cities, towns, villages, industries, and others who severally or jointly are or may be the source of air pollution; and to control and abate the pollution of air in accordance with any code, rule, or regulation which it may promulgate. That board has just completed studies in certain areas of the State; a report thereon is expected in January 1959, but at this moment there is no actual statewide air-pollution control in the State of New York.

That, in brief, is the story on existing statewide air-pollution-control legislation.

Many municipalities have enacted air-pollution-control statutes, codes, and regulations, and a number of them have been able to correct almost intolerable conditions, but there still remains much to be done.

Just as air pollutants and air pollution can cross municipal and county boundaries, it can cross State boundaries and international boundaries, for such boundaries are only black lines on a map, which cannot be seen from the air and which exist only theoretically and not physically.

At this point, it may be argued that if air pollution is interstate, its control should be relegated to the Federal Government.

The Congress of the United States in 1955 did pass an air-pollution-control bill.[12] However, that legislation did not provide for control or abatement of interstate air pollution.

The legislation declared the policy of Congress to preserve and protect the primary responsibilities and rights of the States and local governments in controlling air pollution; authorizes the Surgeon General to prepare and recommend research programs for eliminating and reducing air pollution in cooperation with Federal agencies, State and local governments, air-control agencies, and other public and private agencies; authorizes the Surgeon General to encourage cooperative activities by State and local governments for the prevention and abatement of air pollution; and authorizes the Surgeon General, upon request of any State or local unit of government, to conduct investigations and research with reference to any particular problem of air pollution for the purpose of making recommendation for the solution of the problem.

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[12] Public Law 159, 84th Cong., July 14, 1955.

The pertinent parts of this recent Federal legislation indicate clearly that it was not the intention of the Federal Government to occupy the field of air-pollution control to the exclusion of the States—rather, it would appear to be a clear manifestation on the part of the Congress that it would look to State and local governments to set up air-pollution-control bodies and utilize the power of the State in enforcing air-pollution standards and control.

The problem of air pollution is not a static one—it requires constant study. The expansion of industry, the growth of population, the shifting of industry and population, the invention of new instruments and machinery both for the production and control of air pollutants, all point to a conclusion that the control of interstate air pollution may best be achieved by cooperation between neighboring States with regulations adapted to local conditions rather than by an attempt to enact standards and regulations of universal application.

It is becoming clearer that, much as we may abhor pollution, we find it is the product of our present way of life; we are faced with the practical problem not merely of what we have to control but to what degree it must be controlled, and here we are confronted with the ever-present problem of economics. Obviously, it would be desirable, were it not for economics, to provide the very highest degree of control for all pollution everywhere; that is the hue and cry in every field of government, and particularly in those fields relating to the health and the well-being of the people. The man of vision, as opposed to the visionary man, recognizes that these demands must be balanced and that economics plays an important role in any program. Would we turn back, even if we could, the great march of progress from our present way of living? Here again we need the guidance and support of men of vision, and not merely visionaries to balance the forces of idealism and crass selfish interest to the end that the best public interest will be served. This is not a new principle—it is recognized that no single standard should or could be established to cover the Nation, but rather that the standards must be tailored to fit the uses and requirements of any particular area.

There have been complaints, for many years, of interstate air pollution in the New York-New Jersey area. Accordingly, in 1955, the States of New Jersey and New York, with the consent of the State of Connecticut, authorized the interstate sanitation commission to make a study of the interstate aspects of air pollution in the States of New York and New Jersey and to report on its findings and submit its recommendations, with its proposals for legislation, if any, necessary to carry out its recommendations.

The study was conducted in the summer and fall of 1957 by the interstate sanitation commission with the cooperation of the U.S. Public Health Service, the U.S. Weather Bureau, the U.S. Army Chemical Corps, and the U.S. Bureau of Standards. Dr. Louis McCabe, cochairman of this discussion panel, planned and directed the project for the commission.

The findings of the commission were to the effect that air pollution, originating in the areas in which the study was conducted, is interstate in character—affects public health and comfort adversely and damages property; that while the control and abatement of air pollution at its sources is the primary obligation of the States, counties, or municipalities in which it originates, the problems of interstate air pollution cannot be solved wholly by governmental agencies acting independently of one another, and it recommended that an interstate instrumentality, employing the administrative practices followed by the interstate sanitation commission in the abatement of water pollution, be established to deal with the problems of interstate air pollution.

The commission did not submit any proposed legislation to carry out its recommendations because the time allotted to it for the completion of its study and the submission of its report did not permit the consideration which such proposed legislation properly required, and it requested and obtained an extension of its time to submit its proposals in that regard.

The commission, however, did offer guides for legislation if any should be submitted for consideration, and they were:

1. Such legislation should include a statement of the public policy of the compacting States to maintain a reasonable degree of purity of the air resources of the States.
2. The creation of an instrumentality, employing the administrative practices of the interstate sanitation commission, to deal with the problem of interstate air pollution.
3. That the area of jurisdiction of such instrumentality initially be the regions of New York and New Jersey comprising the New York metropolitan area, with the legislatures of the signatory States reserving the authority to extend such area of jurisdiction upon the recommendation of the instrumentality when the need exists.
4. That such instrumentality be charged with the duty and provided with the authority—
   - (*a*) to collect and disseminate information relating to air pollution, its prevention and control;
   - (*b*) to act as coordinator between air-pollution-control agencies of the signatory States in the establishment by them of rules, regulations, and standards for the control and abatement of interstate air pollution;
   - (*c*) to conduct field studies and investigations related to air pollution as it may deem necessary, or as specifically requested by local or regional control organizations, concerning air pollution arising in adjoining communities; and
   - (*d*) to promulgate rules, regulations, and standards, establish appeal or hearing procedures, issue appropriate orders, and to enforce the same.

The study of the interstate aspects of air pollution was confined to the metropolitan New York-New Jersey area and, accordingly, the recommendation was made that any interstate regulation, initially, be confined to that area.

I speak to you now as a private citizen and not in my capacity of special counsel to the interstate sanitation commission—and my remarks here are to be taken exclusively as my own thoughts and not those of the commission.

It is my theory that the entire area from Massachusetts to Virginia is blanketed by a single air mass, and that any contribution of air pollutants to that mass may well affect the entire area.

With that thought in mind, I have prepared for consideration by the interstate sanitation commission a draft of proposed legislation to deal with the problem of interstate air pollution in that area.

My recommendations, as yet, have not been acted upon by the commission; however, I have received permission from the chairman and the director to discuss them today.

Briefly, such draft proposes that the States of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and the District of Columbia, or any two or more contiguous jurisdictions from among them, by compact, with the approval of the Congress of the United States, create an eastern interstate air-pollution-control region, which shall embrace such area or part of any compacting State, and any waters within or constituting the boundaries thereof, as shall be designated by the legislatures thereof in ratifying the compact or establishing any metropolitan district thereunder, and such compact shall create an eastern regional interstate air-pollution-control board, which shall be composed of one member from each party State. It contemplates further that any State, contiguous with any of the compacting States, may become party to the compact upon the affirmative vote of two-thirds of the States represented on the eastern regional air-pollution-control board, which vote shall include the affirmative vote of the party State or States contiguous to the State under consideration.

Each of the compacting States would pledge, each to the other, faithful cooperation in the control of future air pollution and would agree to provide for the abatement of existing air pollution originating in the area defined as the region, and consistent with such object, to enact adequate legislation which would enable each of the party States to maintain a reasonable degree of purity of the air within and adjacent to such region, and to abate and eliminate such air pollution as constitutes a hazard to the health, welfare, physical property, and other resources of the citizens of the party States, as well as the citizens of neighboring States.

The eastern regional air-pollution-control board would be a body corporate and politic, which would be maintained by appropriation by each of the States party to the compact.

The board would have the power to—

(*a*) encourage and conduct studies, investigations, and research relating to air pollution and its causes, prevention, control, and abatement, and to weather and weather-control measures affecting air pollution and its prevention, control, and abatement;

(*b*) collect and disseminate information relating to air pollution, its prevention and control;

(*c*) advise, consult, and cooperate with other agencies, political subdivisions, other States, the United States Government or any agency thereof, and with affected groups, in any of the fields of its interest;

(*d*) develop a comprehensive program for the prevention and control of all sources of pollution of the air within the region as the same from time to time may be constituted, and make recommendations to the party States;

(*e*) encourage voluntary cooperation by the people, political subdivisions, industries, and persons within the region in restoring and preserving the purity of the air within the region;

> (*f*) act as coordinator between air-pollution agencies of the party States and their political subdivisions in the establishment by them of rules, regulations, and standards for the control and abatement of interstate air pollution;
>
> (*g*) inspect from time to time installations, equipment, devices, and appurtenances thereto that may cause or are causing air pollution or an air-pollution nuisance, or constituting an air-pollution source; and finally—

and this is the only enforcement power granted to the board—

> (*h*) whenever the board finds that any emission or series of emissions or pattern of emissions of air contaminants from any one or more locations in the region constitutes an imminent danger to the health or safety of the people in a part of the region in a party State other than the State where the emission, series, or pattern of emissions takes place, to declare an air-pollution emergency, during the continuance of which emergency the board may issue such order or orders requiring the immediate restriction or cessation of such emission, series, or pattern of emissions as, in its judgment, may be appropriate to remove the danger, provided no such order shall remain in force for a period in excess of 10 days. An air-pollution emergency as declared by the board would terminate 10 days from its inception or upon a finding by the board that the danger no longer existed, whichever period would be the shorter.

To provide machinery for control or abatement of interstate air pollution, the compact would further authorize any two or more of the party States to enter into an agreement within the general purposes of the compact, creating a metropolitan air-pollution-control district and establishing a metropolitan air-pollution-control commission for air-pollution control and abatement in an interstate area comprising parts of those States brought under the authority of the compact. The member of the regional board from each of the States creating such a metropolitan air-pollution-control district would be included in that State's membership on such metropolitan commission, but States so acting could provide for additional representation on such metropolitan district commission or designate one or more existing agencies to act as such commission.

It should be noted that the regional board so recommended would be substantially an advisory body, to develop programs, to conduct research, to disseminate information, and to coordinate activities of air-pollution-control agencies of the member States. It is contemplated that through the exchange of ideas, supported by research, and considered against the background of the peculiar needs, requirements, and conditions prevailing in varying sectors of the region, coordinated steps may be taken to achieve the goal of reasonably pure air over a substantial area of our country.

I have further submitted to the interstate sanitation commission for consideration a proposal that the States of New York, New Jersey, and Connecticut enter into a tristate metropolitan air-pollution-control agreement, within the framework of the eastern regional air-pollution-control compact, pursuant to which there would be created a metropolitan air-pollution-control district which would, initially, embrace, in the State of New York, the counties of Bronx, Kings, New York, Queens, Richmond, Westchester, Nassau, and Suffolk, and any waters within or constituting the boundaries thereof; in the State of New Jersey, the counties of Bergen, Essex, Hudson, Middlesex, Passaic, and Union, and any waters within or constituting the boundaries thereof; in the State of Connecticut, such parts of the State as may be designated by it upon joinder in the agreement; and such other and additional counties or parts thereof of all three States as from time to time might be added thereto by the legislature of a State party to the agreement within which such county or part thereof is situated, upon the recommendation of the metropolitan district air-pollution-control commission to be created by the provisions of such agreement.

The proposed agreement contemplates the creation of a metropolitan district air-pollution-control commission, which in the area defined as the tristate metropolitan air-pollution-control district would have substantially the same powers and duties as the eastern regional air-pollution-control board, and in addition thereto the following powers:

1. After public hearings, to establish and maintain standards whereby and wherefrom, so far as reasonably practicable and possible, it can be ascertained and determined whether any particular emission, escape, or discharge of air contaminants, or any combination thereof, does or does not constitute air pollution or an air-pollution nuisance; to promulgate rules and regulations for the carrying out of the objects of the agreement and for the prevention and control of air pollution and air-pollution nuisances; to delineate and classify different areas within the district according to the density of population, physical conditions prevailing, wind directions and velocities, zoning classifications, and other measures found after investigation to be proper and just, and to adopt regulations for such areas, giving recognition to the fact that a quantity of air contaminants which may cause serious air pollution or air-pollution nuisances in one area or location may cause a different degree of air pollution or air-pollution nuisance in another area or location within the district or within the region, as the case may be.

2. To consider complaints of air pollution, make investigations and hold hearings; issue subpenas requiring the attendance at any place within the district, the giving of testimony, and/or the production of pertinent books, papers, and other records by any person, relating to any matter under investigation, providing secrecy of processes or methods of manufacture or production shall be kept confidential.

3. To inspect installations, equipment, and devices, and appurtenances thereto that may cause or are causing air pollution or an air-pollution nuisance or constituting an air-pollution source, and, in furtherance thereof, to enter upon any building, public or private, during reasonable hours, and to stop, detain, and inspect any vehicle, on any highway, public or private, within the district, or any waterborne craft on any waters within the district.

4. To issue orders directing any person to comply with the laws of the States party to this agreement and/or any political subdivision thereof, including local laws and regulations, relating to air-pollution nuisances and air-pollution sources; to determine whether the orders of the commission are complied with and to bring action in the name of the commission, in the proper court or courts, to compel the en-

forcement, by injunction or otherwise, of any and all provisions of the agreement and/or the orders of the commission pursuant thereto.

As I have said before, we are faced with the practical problem not merely of what we have to control but to what degree it must be controlled, and that here we are confronted with the ever-present problem of economics and the requirement that the administration of any air-pollution-abatement program be accomplished in a manner to balance the forces of idealism and crass selfish interest to the end that the best public interest will be served.

Air-pollution-abatement legislation and regulation can be stringent and its enforcement ruthless—or it may be stringent and its enforcement administered sanely and reasonably and without due hardship to person and property.

Those who may be affected by regulation may contemplate with apprehension the imposition of regulation upon regulation by agency over agency and, while I believe sober consideration of the problems of air pollution can result only in the acceptance of the need for interstate regulation, such regulation itself will not readily be accepted unless there is confidence that its administration will be reasonable and orderly.

The interstate sanitation commission, in the discharge of its duties in connection with the abatement of water pollution, has adopted a policy of conference, conciliation, and consideration that I earnestly believe has secured for it the confidence of the municipalities and the public over which it has been granted jurisdiction, and has established a pattern of administrative procedure which is unique and which may well serve as a guide for governmental agencies. While the abatement of interstate air pollution presents different technical problems from those involved in the abatement of water pollution, the administrative problems involved are substantially similar in character and, for that reason, the draft of legislation which I have submitted to the commission for consideration proposes that the interstate sanitation commission be designated as the agency to constitute the tristate metropolitan air-pollution-control commission which I have just referred to.

That, briefly, is the gist of my proposal. I must repeat that what I have said and what I have proposed are my own thoughts on the problem, and not those of the interstate sanitation commission.

One further problem remains to be discussed.

There are striking instances of international air pollution in the Detroit-Windsor area and in the Port Huron-Sarnia area, where the State of Michigan and the Province of Ontario have a common border. Most of such air pollution arises from heavy marine traffic, but some of it originates from stacks of industrial plants on both sides of the common border and the problem of international air pollution in that area has been under consideration by the International Joint Commission to determine whether it can be controlled by regulations resulting from a treaty between the United States and Canada.

The Detroit-Windsor area and the New York-New Jersey area have a common problem—the pollution of the air by waterborne vessels.

The city of New York some years ago, in an attempt to abate pollution from steamships berthed in the Hudson River, caused a summons to be issued against the Cunard Line because certain of its ships allegedly, while tied up at their Hudson River piers, discharged smoke in violation of the New York City regulations.

In upholding a dismissal of the complaint, the Court of Appeals of the State of New York by a divided court [13] held that the ordinance violated the commerce clause of the Constitution in that it placed a direct burden on interstate or foreign commerce. In its opinion, the court said:

> If the prohibition against the discharge of dense smoke is so applied that a steamship company may be found guilty of a violation because in the operations of great liners, with up-to-date equipment, dense smoke is discharged for a few minutes while a vessel is being prepared for departure, though it is shown that even in the exercise of the greatest care it would be impossible or impractical to avoid such smoke, then it seems to me clear beyond question that the ordinance is unreasonable, obstructs foreign commerce, and exceeds the power of the State.

The majority opinion cited the decision of the U.S. Supreme Court in the case of *Di Santo* v. *Pennsylvania*, reported in 273 U.S. 34, as authority for its ruling that the statute placed a direct burden on interstate or foreign commerce. As you may be aware, under our system of jurisprudence, a determination of the highest court in any jurisdiction becomes a precedent for determination of causes involving similar facts or judicial rights. The Di Santo case involved a regulation which was alleged to be a burden upon interstate commerce in violation of the provisions of the United States constitution which reserved to Congress the power to "regulate commerce with foreign nations and among the several States * * *."

However, since the Cunard case was decided, the U.S. Supreme Court has overruled its own decision in the Di Santo case—and the question now arises: If the Di Santo case had been overruled prior to the decision of the New York Court of Appeals in the Cunard case, would the majority opinion in the Cunard case have been the same or would the conviction of the Cunard Line have been upheld?

It seems to me that in this area there is room for Federal legislation similar to that which now exists in title 33 of the United States Code, which is a resolution giving the consent of the Congress of the United States to the States of North Dakota, South Dakota, Minnesota, Wisconsin, Iowa, and Nebraska or any two or more of said States to agree upon the jurisdiction to be exercised by the said States over offenses arising out of the violation of the laws of any of said States upon any waters forming the boundary lines between any two or more of the said States.

In closing, I feel that I can do no better than to use the language of Mr. Harold W. Kennedy, Los Angeles county counsel, in his introduction to his paper on "Trends in Air Pollution Law and Legislation" delivered at the first technical meeting of the west-coast section of the Air Pollution Control Association on March 26, 1957, when he said:

> We who are working in the field of air-pollution control should feel very fortunate, indeed. This is a relatively new and untested field, and for this reason it is vital, exciting to the imagination, and rewarding in its accomplishments. For the same reason, you may often feel, as I have, that we are members of a safari entering virgin and unexplored territory. Every pioneer has probably experienced the same uncertainty. Most of us have a general knowledge of the present laws applicable to air-pollution control. We can

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[13] *People* v. *Cunard White Star Line*, 280 N.Y. 413.

more effectively accomplish our objective, however, if we are aware of changes, some certain, some speculative, which will soon be upon us.

It is my hope that my discussion today will be of assistance in charting the course into the virgin and unexplored territory of interstate air-pollution control.

Regional Air Pollution Control in the Upper Ohio Valley

Jack R. Adams
Mayor, Wheeling, W. Va.
Representing U.S. Conference of Mayors

It is my assumption that our invitation to the National Conference on Air Pollution is due to the fact that in Wheeling, W. Va., we have incorporated the Ohio Valley Air Pollution Control Council, the first project of its kind ever undertaken in the United States.

On behalf of the people of Wheeling I want to thank you all for the privilege of presenting our story. At the same time I would like to extend an invitation to you to hold your next conference in Wheeling—at the scene of the crime, so to speak—but also at the site of our 2,000-acre Oglebay Park, considered the world's most beautiful municipal park.

Wheeling is the center of what we call the Upper Ohio Valley, an area which extends roughly from the vicinity of East Liverpool, Ohio—a few miles west of Pittsburgh, where the Ohio River bends south—to below New Martinsville, W. Va. Contained within this area of some 80 miles along the banks of the Ohio River are 2 States, 8 counties, and more than 20 incorporated municipalities, almost all of which have received a tremendous influx of major industry. While this industrial growth produced financial trade and prosperity in the area, it also developed another kind of trade. The various communities exchanged their air as freely and generously as they did their money.

To say that Wheeling had an air-pollution problem would be the understatement of the year. We were one of the communities with front-page newspaper photographs of automobiles with their headlights on at 11 a.m., endless accounts of buckets of fly ash being swept off front porches, paint damage, and so on. One of our late physicians used to say, during his war service, that he could identify his hometown buddies by the amount of soot in their lungs. Mr. Charles E. Wallace of the Manufacturing Chemists' Association recently released a paper in which he rated Wheeling as one of the top eight areas in the United States which has a severe air-pollution problem. This was true despite the fact that the population of Wheeling proper is only about 60,000, compared to some other cities of a million or more.

Wheeling is the only West Virginia city with an air-pollution control program. Although our citizens have been aware of the serious air-pollution problem for a number of years, the Wheeling air-pollution control ordinance was not actually passed until February 8, 1955. Located as we are in the heart of the coalfields and the industrial growth area, the considerable opposition to the passage of the ordinance was to be expected.

Prior to that time, some of us in the State legislature had realized the need for State enabling legislation for air-pollution control, but our efforts were blocked by the rural vote. We do expect a bill to be presented to the next session of the West Virginia Legislature, sponsored by the Ohio Valley Regional Air Pollution Control Council.

We consider our Wheeling air-pollution program a success for three basic reasons which are tantamount to success in almost every program:

1. The preliminary engineering and organization work performed by Mr. James Martin, our air-pollution engineer.
2. The fortunate selection of a qualified citizens' advisory commission which established an invaluable liaison with the city council by inviting council's health committee chairman to attend their meetings.
3. The unqualified cooperation of almost everybody in Wheeling with almost everybody else, the people *and* the press.

The Wheeling ordinance established periods of grace: 1 year for commercial and industrial buildings, railroad locomotives, and multiple family dwelling units; 3 years for boats and tugs; 5 years for 1- and 2-family dwelling units. Even before the 1-year period had expired most industries had an acceptable improvement program underway.

There is no immunity to the ordinance. Every commercial, industrial, and apartment building has been inspected by the control department and has either completely corrected its air-pollution problem or will have it corrected within a reasonable time. The city of Wheeling itself had over 30 defective combustion devices which were promptly repaired or replaced. A study is now being made for a municipal pollutionless incinerator program in order that we may do away with the open-burning practice at our sanitary land fill located several miles north of the city limits. We did have a very few reluctant industrialists at first, but the air-pollution-control department has had only four prosecutions—all convictions—since passage of the ordinance.

While the ordinance has been successfully enforced without State enabling legislation, our city solicitor has his fingers crossed. We realize that a test case could jeopardize our entire program.

The Upper Ohio Valley problem is unique in a number of ways. Some of the affected communities which do not have industrial plants within their boundaries and so produce very little pollution themselves, are nevertheless victims of the activities of their neighbors, who may be in a different county or State. There are also several communities which might be described as single-industry towns, where limitations to an effective control program are obvious. Moreover, counties and smaller municipalities frequently incur difficulty in providing adequate funds or securing personnel for an effective and impartial program.

The people of Wheeling realized that it would take more than one bright spot before the Upper Ohio Valley could be considered clean. It was very gratifying then to find that not long after the Wheeling program was put into operation and favorable results were observed, some of these other valley communities came to us for help with their problems.

While the city of Wheeling had no money to put into the area problem (and still has none) the program got off to a good start through what I believe is called an administrative subsidy. Our air-pollution engineer and our citizens' commission gave freely and generously of their knowledge and time. In the beginning, an informal regional air-pollution-control committee was formed to attempt to coordinate and classify the problems of the cities and the industries in their various aspects. Because of increasing interest, and because of the desirability of having a legal identity, the Ohio Valley Air Pollution Control Council charter was signed January 24, 1958, by 15 representative citizens of the area, including civic leaders and city officials. Supported entirely by membership fees, the corporation now has over 100 participating members.

The plan calls for a contractual relationship among the various communities involved. The council is to act as a technical agency in furnishing services; to advise on a uniform ordinance geared to the needs of the various communities and the area as a whole; and to provide a central administrative service and integrated study and research program. It has been emphasized and reemphasized that the efforts of the council will be directed toward compliance and cooperation.

The Ohio Valley Air Pollution Control Council set a national precedent. If it is successful—and we have every reason to believe that it will be—it will not only solve the problem of keeping the polluted air of one of our communities from contaminating the atmosphere of another, but it will also set a pattern for other areas.

While our problem is regional, it is also a series of local problems, and we feel that the solution should be made on a local basis. We must refrain from killing the industrial golden goose; at the same time we believe that our citizens have a right to expect industry to refrain from creating a larger atmospheric cesspool than the one they now live in.

The success of our program in Wheeling proves to us that industries are not put out of business when they are required to reduce their pollution emissions to a tolerable level. It has been our experience that the same industries which bitterly opposed the Wheeling ordinance are now grateful for the fuel savings and clean plant conditions brought about by the efficient operation and combustion equipment. We still have some industries that consider the regional air-pollution control a bad dream and are looking forward to hearing the alarm clock. On the other hand, there are a number of industries that are now installing expensive equipment to collect valueless dust and fumes. These plants are finding that the improved public relations and plant sanitation compensate for the expenditures.

We believe that what is good for one of us is good for all of us. The program is bigger than any one of us, and there is no place in it for sectional rivalry which takes the direction of obstruction. If our region is split up into a score of warring neighbors striving for local advantages at the cost of other localities; if industry, commerce, and society are faced with confusion and conflict in public regulations and public attitudes, we will stunt our own growth. Moreover, it is only fair to new industries locating in the valley to acquaint them with control requirements before they build their plants.

For this we need cooperation from State and Federal services, from valley industries, local governmental officials, civic organizations, and individual citizens. We are very appreciative of the help and advice already given us by the Ohio and West Virginia State Health Departments, and by the U.S. Department of Health, Education, and Welfare. We had the very good fortune to have Dr. John D. Porterfield, Deputy Surgeon General of the Public Health Service, speak to us on "Meeting the Air Pollution Problem." That is as concise a statement of our objective as I know.

We do not have the equipment, the personnel, or the know-how to make air-pollution surveys or perform elaborate analytical work. We are looking forward to early advice and assistance from the Robert A. Taft Engineering Center for a feasibility study and, if warranted, a complete study of the air-pollution problem of the Upper Ohio Valley.

Let us recall the successful 10-year operation of the Ohio River Valley Water Sanitation Commission. It is solving the stream-pollution problem and has proved to the country that pure streams can be a reality. A number of cities are working on sewer projects under grants from the Federal Government.

The same type problems are encountered with regional air-pollution control. We need the same type cooperation, legislation, and appropriations to solve them.

Ohio has the air-pollution problem in other places besides the Upper Ohio Valley—Cincinnati, for instance. West Virginia has it on the Kanawha as well as the Ohio River. This bi-State and tri-State problem exists in many parts of the country. We appreciate very much the opportunity to hear the problems and suggestions of some of these other places.

The natural conclusion is that the Ohio Valley Air Pollution Control Council, Inc. will need an agreement written by Ohio and West Virginia, supported by their respective legislatures, and approved by the Congress of the United States. Under the terms of the compact the two States would pledge a pooling of their resources and regulatory powers for the control of interstate air pollution.

We feel that we are paving the way for the control of interstate air pollution, but we need State and Federal legislation, financial help, and the recognition and endorsement of such organizations as the U.S. Conference of Mayors and the American Municipal Association; but most of all, the support of our sisters in smog.

Sources of Information on Air Pollution

Benjamin Linsky, Control Officer and
Gloria L. Smith, Technical Librarian

Bay Area Air Pollution Control District
San Francisco, Calif.

We believe that this subject is important. The major reason why the air in almost every city in the country isn't as clear as its people would really like it to be is because so many are kept in ignorance about what can be done in a practical way. They are also kept in ignorance about how little it really costs most of the polluters to clean up, in understandable economic terms.

Lies and half-truths help conceal this information from private and public community leaders, including leading business executives. When these deceptions are added to the withholding of information for private financial and public defense security reasons, it is little wonder that the air is as polluted as it is in as many areas. But where can a civic leader obtain information that is reliable about the technical ability and the economics of cleaning up a large or a small operation? Where can he learn of the control equipment now available? And where can he learn which are the few sources for which there are no practical control measures available now?

The first part of this discussion will be concerned with some of the more basic characteristics of information oriented to air pollution.

The second part covers some broad problems of obtaining information about air pollution for use.

The third part describes the present practical sources of air-pollution information.

The fourth part describes newly developing sources of information and possible methods for using them.

Who Is the Audience for This Discussion?

The first audience for this discussion is made up of elected public officials and other civic leaders in business and industry. Each one is from a community that has some excessive air-pollution effects. Each one is deeply involved in community decisions for action or inaction.

The second audience for this discussion is made up of writers and editors. Each one informs the large public in a single community or in a larger area about air-pollution effects, causes, and needs for correction.

The third audience is made up of specialists in related fields of science, communications, government, practice, and industry. Each one knows a great deal about some small aspect of air-pollution work. Each one makes reports that lead others to decisions for action or inaction.

The fourth audience is made up of air-pollution specialists who spend at least half time working on air pollution and its technical and administrative control. Each one is intimately involved in decisions for action or inaction.

I. SOME BASIC CHARACTERISTICS

What Is Meant by Air Pollution?

Air pollution, for this discussion, is generally considered to mean: "Excessive concentrations of air pollutants, recognizable by people because of the undesirable effects on people, on the things people own, and the things people like to do." [1]

The undesirable effects are classified as:

1. Visibility interference.

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[1] Concepts and Phrases for Uniform Approach to Discussions of Air Pollution, Bay Area Air Pollution Control District, San Francisco, 1956.

2. Sky darkening.
3. Soiling of surfaces, light or dark.
4. Annoyance to senses.
5. Damage to vegetation.
6. Other property damage.
7. Interference with production or services.
8. Impairment of health.

The effects are broadly divided into two further groupings:

(a) Localized effects, as from a single point source, or group of sources, on nearby areas.
(b) Areawide effects, extending more than a mile or two from a point source or group of sources.

The physical nature of air pollutants will be classified broadly into the following five categories:

1. Large dust.
2. Microscopic dust.
3. Droplets.
4. Microscopic droplets.
5. Gases.

The above will serve as a framework, or skeleton, on which considerable air-pollution information can be placed in meaningful patterns.

What Is the Purpose of the Information Being Sought?

Generally, information about anything has a value to anyone in the world only to the extent that it serves as a basis for future decisions leading to action or inaction by people.

The first and second audiences, we believe, really want to know if they can clear up the present excessive effects of air pollution in their communities. They also want to know how it can be done in the least troublesome and least expensive manner. And they want to know if the air-pollution controls can be required and still not be economically disastrous to their businesses, their local government operations, and their residents. Finally, they want to know how the community's growth will change the air-pollution effects and whether the growth will be reduced by both the effects of excessive air pollution and by the legislating of air-pollution-control requirements.

The third and fourth audiences—the specialists—want to know more about air-pollution causes and effects. They are particularly interested in identifying, measuring, predicting, designing, installing, and persuading. They would like to have more information about observations and correlations of the original observations and data from their experiences and the experiences of others.

What Is Information and How Is It Communicated?

The most certain information is personal experience. Information based on a person's experience can be transmitted to others by spoken and written words, numbers, drawings, photographs, charts, maps, models, and by several kinds of nonverbal communication, such as a shrug of the shoulders or a lifted eyebrow.

It is important to recognize that the information being transmitted is not identical with the original experience, but is a partial description of part of it by the person who originally experienced it. This is illustrated most graphically when, in everyday life, we later read a description by someone else of an automobile accident that we were in. Or when we describe the accident on the insurance company's accident report form. Even if we tried, we couldn't communicate the sounds or the feeling of dread. And consciously, or with unconscious bias, we select the words and draw the automobile position diagrams in a way that puts us in the least unfavorable light, within moral limits.

The significance of what has just been said is that when one person obtains information from a second person or source, he must judge the competence of the source. He must also judge the maturity of judgment of the source. Finally, he must judge the conscious or unconscious bias that the source applied to his own original experience and to the source's use of the information he received from a third person or source when he decided exactly what elements to report, what elements to exclude, and what words, numbers, charts, gestures, etc., he would use in his report. The report may, of course, be made face to face, or it may be made by phone, by letter, by publication, by movie, by exhibit, by broadcast, etc.

II. SOME BROAD PROBLEMS

Multiplicity of Sources, Pollutants, and Effects

When the first and second audience members are newly approaching the problems of excessive air pollution and its control in their communities, each one is usually staggered by his recognition that there are so many different types and varieties of sources of air pollutants of different kinds. If he doesn't reject the whole problem by picking only one obvious type of source and its pollutants as a sole culprit, it may take him quite a while to analyze the subject and develop a workable system of categories. For this reason there is presented here a list of source and pollutant categories in a table as it was used in a recent technical report from the bay area's official air-pollution-control agency. This listing was suitable for a study of the west coast community's areawide air pollutants. Different listings are needed (and have been used) by other communities and for localized air pollutants. The following is a reproduction of table 7 (p. 25) of this report, presented at a public hearing on October 8, 1958.

The multiplicity of types of sources and of pollutants and the multiplicity of effects present another broad problem in obtaining information. Each industry and trade involved in operating or producing sources of air pollution has its own organization, its own trade and technical publication, and most important, its own lingo developed as a form of shorthand during the many years it has been developing. This can be quickly illustrated by the phrase "vomit stack" which has no meaning except in the papermaking industry, so far as we know. Such strange phrases are not disturbing to the exchange of information because they obviously require definition to others. But the use of the same word or phrase for a slightly different definition causes confusion that results in unnecessary controversy and conflict. The words vapor and smoke illustrate this problem.

There are many technical and scientific disciplines of study and

ESTIMATES OF AIR POLLUTION EMISSIONS (TONS PER DAY) - BAY AREA AIR POLLUTION CONTROL DISTRICT (October 2, 1958)

S O U R C E SOURCE OF EMISSION	PARTICULATES (Dusts-Droplets)(d)					GASES						
	Size Ranges in Microns				Total Parti-culates	ORGANICS					INORGANICS	
	0-1	1-5	5-20	20		HYDROCARBONS		OTHER ORGANICS		Total	Nitrogen Oxides	Sulfur Oxides
						Sat.	Unsat.	Aldehydes & Ketones	Alcohols Esters,etc.	All Organics		
COMBUSTION												
1. Incinerators (c)	←	→ 27	9	37	73	169	128	74	82	453	3	3
2. Heavy Fuel Oil (c)	12	←→	-	-	12	1		1	2	4	86	177
3. Fuel Gas (a)	3	←→	-	-	3	1	-	1	18	20	80	2
SUB-TOTAL	←	→ 42	9	37	88	171	128	76	102	477	169	182
METALLURGICAL												
1. Steel (a)	16	3	2	1	22	-	-	-	-	-	-	2
2. Ferrous (a)	2	1	2	7	12	←				→ 1	-	1
3. Non-Ferrous (b)	2	1	1	1	5	-	-	-	-	-	-	97
4. Kilns, Driers, Ceramic (b)	2	2	2	5	11	-	-	-	-	-	-	2
5. Other (c)	2	2	3	7	14	13	3	←	→ 3	19	-	2
SUB-TOTAL	24	9	10	21	64	14	3	←	→ 3	20	-	104
PETRO-CHEM												
1. Refinery & Allied (a) (b)	←	→ 14	←	→ 9	23(a)	90	8	2	-	100(b)	35(a)	150(a)
2. Chem. & Allied (c)	←	→ 5	←	→ 58	63	51	7	←	→ 28	86	8	68
3. Food & Kindred (c)	←	→ 1	←	→ 2	3	10		←	→ 2	12	10	5
4. Paint & Allied (c)	←	→ 1	←	→ 1	2	78	12	←	→ 34	124	2	11
SUB-TOTAL	←	→ 21	←	→ 70	91	229	27	2	64	322	55	234
TOTAL	←	→ 96	19	128	243	414	158	78	169	819	224	520
OTHER												
1. Transportation:												
a. Gasoline (b)	←	→ 16			16	480	52	7	8	547	222	24
b. Diesel (c)	←	→ 10	6		16	47		2	5	54	15	6
2. Agricultural Burning (c) (e)	←	→ 25	10	25	60	375	350	180	95	1,000	2	4
SUB-TOTAL	←	→ 51	16	25	92	902	402	189	108	1,601	239	34
GRAND TOTAL	←	→ 147	35	153	335	1,316	560	267	277	2,420	463	554

(a) Firm data
(b) Fair data
(c) Estimate

(d) Only tonnage figures reflect firmness of data (a, b, & c) - particle size is based on meager data and judgment factors (exception is metallurgical data based upon accepted published data).
(e) Based on seasonal burning.

research, each with its own societies, conferences, symposia, committees, and journals that report on observations of work done in the physical sciences and the life sciences. New work is being done to improve on the measurement and abatement that can be done in a practical way already. New work is also being done to measure and abate the few significant things that can't be done in a practical way now. But a great deal of scientific work has been done for other reasons than community air-pollution control that could be applied to air-pollution problems if each researcher knew more about the others' problems and accomplishments, unhampered by private and public security limitations.

The waste in calendar time, man hours, and money is shocking to a technical specialist in a public air-pollution-control agency when he learns of major errors in plant process engineering that could have been avoided if the plant engineer had been allowed to discuss his problems more openly. It is equally disturbing for air-pollution-control agencies to do extensive work on a survey and then hear from a company air-pollution specialist, "Oh, yes, we knew that a few years ago but didn't bother spreading the word around." This barrier of silence seems to be breaking down, however slowly.

III. PRESENT PRACTICAL SOURCES OF INFORMATION

Does the Information Now Exist?

It is necessary to distinguish between:

1. Information that already exists.
2. Information that doesn't yet exist but that can be readily obtained by using known existing methods and techniques, such as the degree of soiling, visibility, or corrosion damage effects in a community just starting to tackle its problems.

This discussion will be limited to information that already exists.

Talk With Someone Who Knows the Subject

No attempt will be made here to define clearly how to judge competence because the first and second audiences are skilled in detecting the differences between a person who knows his subject and a person who just knows something about the subject.

It takes time and, usually, money to find and to reach the man with experience to learn from him what you want to know—even if it is only a long-distance phone call to a public official. (This is usually the least expensive way, in the long run, as most professional consultants know.)

Obviously, the people in official local, regional, State, and national air-pollution agencies and in the air-pollution divisions of industries, consulting organizations, and research groups (and those people they work with most closely) are the starting points for any civic leader who wants to learn. As mentioned earlier, the problem of evaluating the competence and the built-in bias (unconscious or deliberate) of the air-pollution specialist is a common type of problem in any specialized field.

The men with experience in the actual control of air pollutants are the engineers, chemists, and occasionally, physicists, meteorologists, and biologists, who design, install, and test air-pollution-control equipment and methods. They are also the plant and process engineers, the control equipment sales and installation engineers, the fuels engineers, and the source testers and the inspectors employed in private testing laboratories, semipublic and private research institutes, and public air-pollution-control agencies, as well as in university and Government research groups.

In addition to those who are air-pollution-control specialists in the ordinary meaning of the term, there are many others who are concerned with some types of air pollutants that are traditionally called something else. Radioactive airborne materials, pesticides, herbicides, fumigants, eroded soils, pollens, rocket fuels, biological warfare materials, meteorites, contaminants in long-range submarines and space vehicles, volcanic emissions, plant growth hormones, fruit ripening agents, and perfumes are some of these materials.

In the fields of sampling, identifying, and measuring air pollutants, their transport, and their effects, we add to the people already mentioned those meteorologists who specialize in climatology and diffusion, as well as industrial hygienists, biochemists, biologists, corrosion engineers, paint specialists, rubber technologists, laundering and dry cleaning specialists, building and roof maintenance specialists, automobile claims agents, air conditioning engineers, automotive engineers, visual range physicists and physiologists, industrial hygienists—the list is much longer than one can easily read.

As a matter of fact, a list of the different occupations, unskilled, skilled, professional, and scientific, who have some knowledge about some phases of air pollution and its control almost reads like the Dictionary of Occupational Classifications.

The Membership Directory of the Air Pollution Control Association, with its listings of members' names by alphabet, by committee assignments, and by geography, is the most useful source of names for direct conversation and correspondence.

To sum up, there is direct knowledge available by conversation and correspondence with:

Polluters;
Experimenters;
Corrective designers;
Persuaders;
Victims;

and their suppliers, employees, representatives, and spokesmen.

Read About It

In addition to, or in place of, personal discussions and correspondence with an air-pollution-control specialist, the use of the publications by him and his employee is the next best source of information. Selecting the exactly useful information from the tremendous mass of publications about everything has been somewhat eased by the many-sided, cross-pollinated national voluntary membership organization in this field:

Air Pollution Control Association
4400 Fifth Ave.
Pittsburgh, Pa.

The APCA Abstracts, the Journal of the Air Pollution Control Association, and the proceedings of its periodic conferences are the single most useful group of publications available. Because these publications rarely contain any critical comments on the articles, they must be read with due caution. Often, critiques are offered by small private groups in corridors, and at semisocial small tables. They do not become available to those who are not present at the specific conference except by that important channel of information known as the high-fidelity grapevine. This is otherwise known as unpublished judgments and information from a speaker judged by his listener to be reliable.

The general publications of most other private, public, and volunteer organizations (there are a great many) that have committees or divisions on air pollution are also useful, but of course, are generally not as concentrated on the subject of air pollution, and therefore require a library search.

It usually takes a great amount of time to do a library search. For this reason, a small number of special technical air-pollution libraries have come into being at public and quasipublic organizations. In the United States they are located at:

Air Pollution Control Association, Mellon Institute, Pittsburgh, Pa.
Air Pollution Foundation, San Marino, Calif.
Armour Research Foundation, Chicago, Ill.
Battelle Memorial Institute, Columbus, Ohio.
Bay Area Air Pollution Control District, San Francisco, Calif.
Los Angeles County Air Pollution Control District, Los Angeles, Calif.
Robert A. Taft Sanitary Engineering Center, Public Health Service, Cincinnati, Ohio.
Stanford Research Institute, Menlo Park, Calif.

These are in addition to the generally smaller air-pollution sections of libraries maintained by many public libraries, technical societies, trade associations, universities, individual industries, and other research groups.

The newest of these was specially designed and assembled as a single major project at an initial cost of $50,000. Its primary objective was to reduce the time and cost to plant and process engineers in the bay area. Tax funds were allocated by the Bay Area Air Pollution Control District Board of Directors for a contract with Stanford Research Institute for "The Design, Establishment, and Operation of an Information Center on Air Pollution." The work was completed 8 months later, in January 1958, when the completed microfilm library and index were turned over to the district. It now bears the name: Information Center on Air Pollution, Bay Area Air Pollution Control District, San Francisco, Calif. This is the first public air-pollution library in the country to be organized under the fast and easy-to-use Uniterm Coordinate Indexing System, whereby a single article or a group of reference items covering a broad area can be located within a few minutes time. The predigested selection of published and unpublished articles, symposia and technical conference material on microfilm, plus some original sources, is cross-indexed according to accession number and subject matter key words on 5" x 8" file cards. The index and microfilmed articles are contained in one 7-drawer filing cabinet, while large books and a few standard library tools are kept in original form. A complete set of the index cards for 7,000 articles has been microfilmed, as is being shown here, so that it can be stored in a safeguard vault and for reproduction of complete sets for sale to others. Because of the reproducibility feature, negotiations for sale of copies of the index are underway at the present time with one State air-pollution agency and with one Federal agency.

Most of the content of the Information Center on Air Pollution is on microfilm (about 6,500 publications), the other 500 being in the form of "hard copy." Subject to the usual copyright limitations for research work, reproductions are made at cost from the microfilm for others.

The design of the system is such that when the total number of publications becomes large enough to justify it, the visual searching of the index can be replaced by mechanical searching using simple punched card machine sorting or computer storage and selection.

Because of the value of consistent indexing and the fact that only one group can assign the individual accession numbers used for the cross-indexing with the visual index card system, it is recognized that maintaining the system up to date requires coordination with the parent library to a moderate degree.

Information about air-pollution effects, types and concentrations of air pollutants in the atmosphere, meteorology and terrain, sources of air pollutants, physical methods of control of the pollutants at the source, and the economics and administrative methods of control are being increasingly reported by those who are actually doing the work.

One of the most thoughtful discussions of "Sources of Air Pollution Literature" is the article by Janet B. Murk, Barrett Division, Allied Chemical and Dye Corp., in the May 1955, *Industrial and Engineering Chemistry, 47* (5), 976–81. Her article considers the problem of terminology, which is in dire need of standardization. The phrase "vomit stack" indicates the nature of this problem.

For those who are interested in detailed methods of storing and retrieving published information, the journal *Special Libraries* will be useful. It also discusses new developments such as the increasing availability of technical information from behind the Iron Curtain. (This is probably a fair exchange for the 1951 Cloud of Alberta, Canada, forest fire smoke that traveled across the United States, past Detroit, Cleveland, and Washington, over Scotland, and was reported last seen crossing the boundary into Poland.)

Developments in librarianship include increasing use of a microfilm library such as ours. There is an excellent article by Loretta J. Kiersky, in the November 1957 issue of *Special Libraries* that describes, discusses, and lists the various microrecording and copying techniques, with a good bibliography and a directory of manufacturers and reproduction service centers.

In the rush to embrace and use index systems with names like Keysort, Peek-a-boo, Batten, Zatocoding, Matrex, IBM, and Minicards, it is wise not to forget the traditional form of indexing available—the 3 x 5 library cards.

Excellent technical and scientific libraries are available for visit. When a publication is not available nearby, it can always be obtained by interlibrary loan, or photocopy or microfilm, at the request of any nearby recognized library.

Outstanding libraries directly available to the public include the

John Crerar Library in Chicago, the Library of Congress in Washington, D.C., the Kresge-Hooker Library in Detroit, and the Linda Hall Library in Kansas City.

Medical Information

Because medical research into health impairment has only recently been expanded in volume, there is little point in extensive study of this subject by the first audience. Until some more definitive and authoritative conclusions are stated publicly, the best-known information that can be found as a basis for action can be summed up "What you don't put into the air won't hurt you." The disasters that have occurred are well covered in the air-pollution references that have been listed here.

For the second, third, and fourth audiences, the press releases by the public and voluntary medical research organizations are sufficiently widespread to serve those who don't find it necessary to subscribe to the *Current List of Medical Literature*, of the Armed Forces Medical Library. This journal is also covered by APCA Abstracts.

Limited Availability of Some Published Reports

A large number of useful reports that are not noted in standard library sources receive limited circulation because of costs. Control equipment manufacturers, local air-pollution-control agencies, and privately sponsored research groups, are sources of this nature.

Another large number of potentially useful reports are practically unavailable to civic leaders in and out of local government because of company or military security reasons.

IV. NEWLY DEVELOPING SOURCES OF INFORMATION

Reports of Case Histories of Industrial Installations

An increasing number of companies, in cooperation with equipment suppliers and local air-pollution-control agencies, are authorizing the publication of identified or identity-concealing case histories of successful air-pollution-control installations. These may be expected to be stimulated by the fact that concealment of successful installations is more difficult because of the activity of Federal specialists and because of publications such as *Smog News*.

Reports Supported by National and International Groups

The Federal Government defense agencies, under the stimulus of the Public Health Service and others, is releasing increasing numbers of previously classified reports that are useful.

An increasing number of community air-pollution studies and surveys, some of them partly financed by the Public Health Service, are being produced and publicly reported. The previously unpublished work of the Los Angeles County Air Pollution Control District will be especially useful.

An increasing number of industrywide manuals on practical control methods, such as that of the American Foundrymen's Society, will be published.

An increasing number of these publications, when edited by balanced committees, such as those of the Air Pollution Control Association's Technical Council, can be expected to be as well received as are comparable official publications of other organizations. Examples are the National Safety Council, the National Fire Protection Association, and the American Society for Testing Materials. (Each of these, by the way, is involved to some degree in air-pollution-problem work.)

An increasing influx of translated publications on air pollution is developing because of the problems and solutions being developed in other countries.

The national news wire services are carrying increasing amounts of news about air pollution which serves as leads for those who are interested.

Improved Storage and Retrieval of Reports

With the proved value of a microfilm library; with the availability of the index of the Bay Area Air Pollution Control District; with the proved value of documentation centers such as those established by the AEC and ASTIA; with the availability of leased wire facsimile transmitting machines; and with the availability of high speed index code storage, search, and retrieval systems; it can be expected that published reports will be made immediately available on any subject involved in air pollution. These reports can be supplied to any person or organization interested, with a minimum expenditure of time and money. If this complete system should develop, the work of the Bay Area Air Pollution Control District in establishing its special air-pollution library using a coordinate index system may turn out to be one of its most valuable contributions to the air-pollution field. This will be a partial exchange for the benefits it received from the work of others during the past 50 years and more.

V. SUMMARY

Information about air pollution is becoming more readily available, but is still costly.

The best source of information is the person who knows the subject, but his competence and bias must be evaluated.

The major interferences with the exchange of existing information continue to be, as was reported a year and a half ago:[2]

Documentation.
Security.
Semantics.

APPENDIX I

Case Histories of the Use of Sources of Information by Benjamin Linsky

1. A steel mill, in a small city that adjoined a very large city, was contributing significantly to visibility interference in its own and in neighboring communities for miles around, including a city in a neighboring country. The uncontrolled open-hearth furnaces were major sources at this plant. The vice president in

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[2] Fifty Years Backward and Forward in Air Pollution Control, Benjamin Linsky, Proceedings of the Air Pollution Control Association Golden Jubilee Meeting, St. Louis, Mo. (June 1957).

charge of engineering told the mayor (or tried to) that there was no known way of controlling the microscopic dusts and droplets from open-hearth stacks. An air-pollution-control-agency engineer from a neighboring city was present who called attention to the effective installations at Fontana, Fairless, and Los Angeles County, about which he knew, partly from the grapevine, partly from personal observation, and partly from publications that were not yet in the technical literature. After some debate about whether or not the installations were failures or hazardous, the executive finally agreed that there were available practical solutions and that the costs were not ruinous (a small percent of plant investment), but that his management would do nothing "until we have to." It is important to note that, had the other steel mills not told their story on and off the record, the mayor could not have been furnished with information on which to base a social-economic-technical-political decision as to regulation requirements.

2. Several local public and private community leaders from cities in an area heavily endowed with cement plants were, together with a professor from a local university, in Washington, D.C., to testify on a bill to provide some fiscal and technical assistance on air-pollution control. They testified about the heavy soiling, damage, and annoyance to senses caused by the air pollutants from the cement plants. They were pleading for research to provide answers so that the cement plants could clean themselves up. No one had told them until they learned it that same day from air-pollution-control-agency engineers from two large cities that effective, economically safe pollution-control equipment had already been installed in cement plants in other parts of the country at investment costs of less than 8 percent of plant investment, with some cost regain from captured products. A search of the literature showed very few publications at that time about control equipment case histories in this industry. It has been interesting to follow the progress of these several neighboring communities in developing a control program and obtaining corrective action.

3. A few months ago, the city engineer of a city in a neighboring country wrote a letter to one (or more) air-pollution-control agencies. He inquired whether it was true, as he had been told, that fly ash control devices for wood waste fuel-fired boilers were so expensive as to justify a threat by the plant owners to move out of town if air-pollution-control requirements were established. He learned of the relatively modest costs of such equipment. He also learned that, to the contrary, industry moveouts due solely, or even primarily, to air-pollution-control requirements are really unheard of.

APPENDIX II

Listing of Information Sources

I. GENERAL

A. NATIONAL AGENCIES

Atomic Energy Commission, Technical Information Service Extension, Oak Ridge, Tenn.

Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Va.

Government Printing Office, Washington 25, D.C.

Office of Scientific Information, National Science Foundation, Washington 25, D.C.

U.S. Department of Health, Education, and Welfare, Public Health Service, Washington 25, D.C.

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THE JARGON OF MACHINE LITERATURE SEARCHING. Thomas H. Rees, Jr., and Allen Kent. Western Reserve University, Cleveland 6, Ohio. Paper presented before the division of chemical literature at the 131st national meeting of the American Chemical Society, Miami, Fla., Apr. 11, 1957.

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AIR POLLUTION HANDBOOK. Edited by Paul L. Magill, Francis R. Holden, and Charles Ackley. McGraw-Hill Book Co., Inc., New York (1956).

BIOLOGICAL ASPECTS OF AIR POLLUTION, AN ANNOTATED BIBLIOGRAPHY. Harry Heimann, H. Merton Brooks, Jr., and Donald G. Schmidt. Federal Security Agency, Public Health Service, Division of Industrial Hygiene (Apr. 1950).

AIR POLLUTION LITERATURE. A LIBRARY METHOD. Claire Foster Weaver and James C. Martin. Philadelphia Department of Public Health (Mar. 1, 1955).

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Cooperation in the Administration of Air-Pollution Control

Raymond E. Wetzel
Superintendent, Bureau of Air-Pollution Control
City of Indianapolis, Ind.

We in Indianapolis are, like Mayor Adams from Wheeling, in the center of a coalfield. The only trouble is that our coal has a much higher volatile content than his does; therefore, it means more smoke.

The Indianapolis Bureau of Air Pollution Control, after adopting a public educational and cooperative program to clear the atmosphere over the city of manmade air pollutants, can now report a definite improvement in atmospheric conditions and steady progress toward its goal of making the city of Indianapolis one of the most smoke-free, soot-free, and dust-free industrial communities in America.

In Indianapolis today it is no longer necessary for any resident to peer through a pall of dense smoke or smog to observe the glory of a sunrise or the beauty of a sunset. The mutual efforts of the bureau of air-pollution control and industrial plant management have resulted in the replacement of many obsolete smoke-producing fuel-burning units with up-to-date fuel-combustion units, and necessary repairs to otherwise efficient fuel-burning equipment units to eliminate the emission of air pollutants from smokestacks. This has practically removed Indianapolis industrial plants from the lists of air-pollution producers.

The air-pollution problems now receiving the attention and study of the Indianapolis Air Pollution Control Bureau consist for the most part of smoke from household chimneys, smoke and fly ash from improvised incinerators and open trash fires, dust from cement-mixing plants, and the emission of noxious fumes and gases from the exhaust pipes of gasoline- and oil-powered motor vehicles. In the interest of public health and welfare, every possible means for the solution of these problems is being thoroughly explored.

Defective or antiquated equipment, plus improper operation of same, has been the major factor causing dense smoke and smog in the past. This condition is rapidly improving through the application of new and modern fuel-burning equipment and improved firing practices. Approximately $10 million has been expended during the past 4 years for modern combustion devices and major repairs to equipment.

Engineering, education, and cooperation of this department and plant management have resulted in approximately 90 percent less pollutants in the air.

Indianapolis now burns in excess of 3 million tons of soft coal, 85 million gallons of fuel oil, 200 million gallons of gasoline, and 3 million gallons of diesel oil per year in an area of 65.15 square miles. We have in excess of 10,000 manufacturing and commercial plants and 300,000 automobiles, trucks, and buses. All of these are capable of polluting the air we breathe. Thus, the problem of air-pollution control is not merely that of today, but of the added burden tomorrow will bring.

It is gratifying that our city won the Cleanest City Award in its population class for the years 1955, 1956, and 1957.

Recent dustfall tests show our city to be 26.80 tons per square mile below the national average, which is 50 tons per square mile. The total dustfall average in Indianapolis last spring was 23.21 tons per square mile.

On Monday, December 13, 1954, the Indianapolis News started a series on "Improvements Needed" and No. 1 was smoke abatement. Since that time, approximately 5,000 manufacturing plants and business firms have cooperated by installing modern combustion equipment and improving their firing techniques through an educational program started by this bureau. Approximately 7,000 educational pamphlets have been mailed out and many on-the-spot firing demonstrations have been given.

We feel that we have made some improvements, because Indianapolis has not experienced a major smog since December 12, 1955, and this has been accomplished without a single court case.

We found some time ago that the collective cooperation of the coal industry, industrial plants, the public, the railroads, and smoke-control groups was most important in waging a successful battle against the smoke evil. Today we know that polluted air is not necessary and is unneighborly. Smoke is a result of inefficient and incomplete combustion. Coal is not the only source of smoke. A kerosene lamp will smoke when there is not enough oxygen to support combustion. Natural gas when burned will make smoke too, if it does not get oxygen. Black smoke is no longer an indication of prosperity; it only reflects bad management and waste.

People like to live where the air is clean. Clearing the air over Indianapolis has been a major factor in bringing more people there. Increased population means more business and industry, which, in turn, means more prosperity for everybody.

DISCUSSION

Dennis J. Sullivan. I was interested in Mr. Cooper's discussion of a method of controlling air pollution where it involved more than one State. What struck me as I listened has come to my mind on several occasions before.

Our ordinary concept of government, as I understand it, was first on a municipal basis, where they had home-rule rights, the right to adopt ordinances regulating their own community. Where that didn't succeed, they could go to the next unit of government, the county, and, finally, to the State.

But in recent years there has been a trend toward the setting up of what I call supergovernments. We have sewage authorities, incinerator authorities, and parkway authorities, all sorts of autonomous bodies that are not responsible directly to the people, being set up to regulate various conditions and various situations that influence people in these areas that I refer to.

Mr. Cooper said, regarding some proposed legislation, that the interstate commission would only come into play where there was something involving more than one State; in other words, where there was air pollution from one State going over into another State.

He also referred to the interstate commission as a coordinating agency. If this interstate body was given authority to supervise the situations he describes, there would be little point in trying to coordinate the State and local agencies. The latter would be rendered ineffective because the interstate sanitation commission's regulations would take precedence over theirs.

I am not an air-pollution specialist. I am a local city health officer, but we are very keenly interested in air pollution. We do have in our State an air-pollution commission. We think they are doing a splendid job for the time they have been in office. It is my feeling that in areas where there are agencies attempting to do a job, they should be offered the opportunity to do that job before imposing upon them another agency which, to my mind, would only confuse the issue.

Mr. COOPER. The question you raised was brought up some 20 years ago in connection with the abatement of water pollution. Municipalities, which were charged originally with the responsibility for the abatement of water pollution from their own sewers, failed properly to discharge their obligations, and there was similar comment that the creation of a superagency over local municipal water-pollution abatement, a board that would have superjurisdiction over State water-pollution control and other activities of the State health department would be the imposition of one agency upon another.

Nevertheless, the experiment was tried and the interstate sanitation commission was established in 1936 for the abatement of water pollution in the interstate area, the New York metropolitan area, and in the 20 years that commission has been functioning it has succeeded in substantially abating the pollution of the tidal waters of the area and is progressing in the abatement of water pollution in the large metropolitan areas around New York City.

The theory behind the proposed legislation for air pollution is based on the same consideration, that the regulations, the standards, the codes which might be established by an interstate body would be based upon the requirements of the local area. They would not be a superimposition of new standards. The purpose would be to determine whether the standards in any particular locality were sufficient to abate, as far as possible, the pollution arising from that particular area and which might contribute to interstate pollution; to coordinate the activities of local agencies, because we feel that the abatement of pollution is primarily the responsibility of the local community in which the pollution is produced.

There will possibly be instances where a local municipality, for political reasons, for economic reasons, or for any number of other reasons, will fail properly to discharge its obligation in the control of the production of air pollutants, where a State body, charged with the same responsibilities as the local community, may fail properly to discharge its obligations or where a State body might seek the assistance of an interstate agency, because it felt that it could not discharge its own obligations.

The interstate sanitary commission or the tristate convention does not propose to eliminate the activities of local enforcement activities or statewide activities, but to cooperate in the activities of all these authorities to the end that the air over the community may be clean.

Mr. SULLIVAN. This commission you refer to will establish rules, and one of the rules they adopt applying to air pollution would, in my opinion, nullify the rules and regulations and ordinances and State laws we now have on our books, because they would be, apparently and obviously, in conflict with the tristate commission's rules and regulations.

Mr. COOPER. Certainly, any code of a local municipality not inconsistent with a regulation adopted by an interstate agency would not be nullified. If they both have the same intent, while their wording may not be the same, if the local code is not inconsistent with any regulation promulgated by an interstate body, it would not be nullified.

Mr. LINSKY. In Detroit we found that we were able to establish excellent liaison and relations with our neighboring city across the international line. This is Windsor, in Ontario. We had far more difficulty in establishing similar cooperative levels of control, particularly on the microscopic dust droplets and gases that go widely across boundaries, with neighboring cities in our own State.

In the bay area, a six-county special district was set up under State law. It does not occupy the whole field. Any city or county—there are 70 cities and 6 counties—can impose greater restrictions to any extent it wishes if they are not in conflict.

It urges and, by virtue of the compulsion feature built in, ordinarily called the enforcement procedure, provides for civilian judges, with the intent that the cities and counties adopt their own parallel and, if desired, more restrictive legislation, providing for easier and quicker enforcement of those things that require easy and quick enforcement.

So there is not an inconsistency in a large area setting up a higher ceiling, and anyone else can build ceilings below it.

JEROME WILKENFELD. Mr. Linsky stated that each succeeding level can make more restrictive rules than the one immediately above. This tends to put tighter and tighter controls on everyone involved in this problem. We have to be careful that we temper this with some judgment. I think we want to be careful of the superorganization that pyramids one on another, or we will end up with rules that are too restrictive.

We do have to keep in mind there are certain minimums that we will have to reach. A lot of these haven't been determined but they will be in the next few years. We are moving rapidly in the technology involved here. We should watch out that we don't squeeze anybody harder than necessary merely because all the added rules are supposed to be "more restrictive." I prefer you to say "equal or better."

Mr. LINSKY. That is right. This points up a defect in the law that set up our district, and we are asking for correction. It was a complete oversight. Our legislation says "stricter than." Nobody thought of it at the time. I will restate it to make sure there is understanding. "Equal to or more restrictive than" is what it should be. It should not be necessary in order to be able to operate at a local level to be tighter than the next level up.

Mr. Wilkenfeld. Also, when you set up larger areas, you start making blanket regulations which may not be applicable all over. In the New York State law we have taken that into consideration by saying that different parts of the State may have varying requirements. This whole conference has pointed that out. We hear from the poor unfortunates in Los Angeles, who happen to have a particularly bad topographical setup, and the serious problem there requires extremely strict regulations, and some of them have gotten quite rabid about it. We have to be careful it isn't carried over into areas that are well ventilated and don't require that sort of thing.

Similarly, we have to be careful that, in setting up any of these superagencies, you don't make blanket requirements that local communities in a particular instance may fall under and have to have a needlessly tight regulation just because there is another area in the group that does need it.

Mr. Linsky. Just on the west coast, I know there are three additional areas increasing in population very rapidly, to the extent of doubling every 15 years. These three, in addition to the Los Angeles Basin, are faced with the same problem of reduced ventilation in rather homogeneous areas. The bay area, San Diego, and Sacramento Valley, which is much larger, have a higher terrain potential for poor ventilation.

The point is well taken. You will recall in Mr. Kennedy's discussion of Los Angeles County and neighboring counties, with respect to the regional setup, that they are afraid of having their essential standards diluted.

One thing you tend to get is the lowest common denominator in a larger area regulation, unless you set up a truly workable acceptance of variance procedure for the unusual pocket, if you have pockets that are in the same or a different economic area but in a different area as far as actual air pollution is concerned.

Mr. Cooper. Mr. Wilkenfeld, the proposal which I read this morning provided that this commission would classify different areas within the district according to the density of population, physical conditions prevailing, wind directions and velocity, zoning classifications, and other criteria found after investgation to be proper and just, giving recognition to the fact that a quantity of air contaminants which may cause serious air-pollution nuisances in one area or location may cause a different degree of air-pollution nuisance in another area or location within the district. It was what you were discussing that we had in mind when this was proposed.

T. J. Wells. There is an example of one of those supercommissions in effect on the Ohio River. Eight States formed a compact. The Constitution of the United States has several ways by which you can put Federal laws into effect—that is, laws crossing State lines—either through constitutional amendments or through the method known as the compact.

The compact was little used until this water compact was put into effect. I believe you have the same thing in the New York area.

These eight States, however, after they had formed this compact, set up their superstate commission, and on the Ohio side of the river, from Pittsburgh all the way down to Cairo, Ill., began to build sewage-disposal plants.

This superstate, in its supreme wisdom, built one on the Kentucky side of the river, where I happen to live. Two counties take the polluted waters from all the municipalities, and they built a plant without digestors. They burn raw sewage in it.

When complaints were made of that, they went to the point of actually telling the people of Covington and Newport, Ky., cities of 60,000 to 75,000 people, "We are running this, and you keep your mouths shut."

They actually came out in the newspapers and made public statements to that effect; "We have the authority and we are doing it."

So a State judge closed the plant up and for 18 months he said, "I will jail the man who opens that plant," until they finally spent a million dollars on deodorants.

They didn't put digestors in, and to this day there are lawsuits against the commission, and they are wondering if they can be sued, for they are claiming immunity under the law.

I say to all the experts in all lines—and I am one of them for the railroads—think long and hard before you give any commission superpolitical power, if it isn't answerable to your State legislature.

If a plant exists in one State, I say to you that, with pressure brought from a neighboring State through their Governor and their proper commission, you can stop emission of anything out of any plant without these commissions.

Sidney Zagri. As public relations officer for the Teamsters Joint Council 13 in St. Louis, I want to express a citizen's point of view on the excellent statement of Donald Wagner on community sentiment and involving the community in the problem of air pollution.

The situation in St. Louis is not a unique one. We have a fairly good air-pollution ordinance, but there hasn't been enough citizen involvement in the problem by the health authorities, so that the type of support that is needed to get the funds to make this air-pollution ordinance effective hasn't taken place. I would like to ask what the experts can do to translate what they know in terms average citizens can understand and their local organizations can respond to.

This, of course, is a big order. We in St. Louis have in our particular organization a system of community stewards. Each steward represents 25 members of the local union in his particular neighborhood, and I only mention this because I think this is the type of organization that could be adopted by any community organization as these particular problems arise. In this case it was air pollution in one part of the city, and we had air-pollution grievances filed in 15 different parts of St. Louis.

We had a march on city hall last July with a picket line going back and forth to advertise the problem. The newspapers and television programs picked it up and St. Louis became air-pollution conscious. Finally, we had a hearing before the board of aldermen last week. We had a packed room. I only point this out as an indication of the possibilities of citizen participation.

This idea of a national air-pollution conference is an excellent one, because it focuses the attention of America on this all-important problem. Perhaps we should also have a series of air-pollution conferences at the local level, because there is where the problem has to be dealt with.

If there is any one single objective to be gained at this conference, it is the mobilization of public opinion, so that you experts can get the funds necessary to hire the staff necessary to get the job done.

So I would suggest that, wherever possible and whenever possible, we in labor—and management, too—join in some type of postconference work at the local level, inviting the citizens on the basis of management-labor responsibility toward the community on this problem of air pollution.

Mr. Linsky. In a community you have many elements that consider themselves neither management nor labor. Except in some rather unusual circumstances, regardless of who takes the initiative, you need a broader base in order to do the job than just a local management-labor air-pollution conference.

Mr. Zagri. I was thinking of it as a starting point. Those are two substantial bases of the community from which you start. The other community groups would also become involved in the process. I am thinking from the standpoint of the necessary mechanics. The chamber of commerce and the central trades are two substantial groups that could start such a program.

Mr. Linsky. This may be true in many communities, but your program has to be tailored to fit the specific community needs. A blanket recommendation might be almost frivolous.

Mr. Zagri. Another possible approach would be to have a university in a given area call a conference which would involve basic community groups, including labor and management.

Mr. Linsky. There are other possibilities. In communities like Cincinnati there are Red Feather agencies that can operate in the same way. Other communities have still other kinds of groups already in existence. My own feeling as a professional is that existing social action agencies in a community be utilized to the maximum wherever possible rather than generating a brand-new social group. If there are in existence elements that can be utilized and possibly even strengthened by being used, just as you strengthen an arm by using it more, it might be well to utilize them.

Mr. Wilkenfeld. Mr. Linsky, I am surprised that you, as a past president of the Air Pollution Control Association, didn't mention the local chapters of APCA which, in a lot of communities, do continue this sort of work to further action.

Mr. Linsky. They are too much secular. They include the pollutors, the pollution-control-equipment people, the pollution-product manufacturers and distributors and their representatives, and the pollution-control people. They do not include the women's clubs, the chamber of commerce, and the others. I was not deliberately omitting them, but they are not the community social action group that I think was in the mind of the proposer.

Mr. Wilkenfeld. I was thinking mainly from my own experience in our local group, where we have been trying to develop interest among those other groups.

Mr. Linsky. Most sectional groups are limited to those who are professionally concerned with air pollution, its control and avoidance, rather than the general community. Again you have a special situation in the Niagara Falls area, and by its nature those who know the community would know this wouldn't fit another area.

Richard W. Smith. This matter of getting the general public interested is very important. Somebody has mentioned here participation of the chambers of commerce. Things that local chambers of commerce have been doing in recent years might be adapted to this problem. One is Business-Education Days, when the businessmen visit the schools to see how the schools are operated and what their problems are. Then they invite the schoolteachers and schoolchildren to visit business establishments in town to see what their problems are.

That same method could be applied to this. When your local agency or your State agency has a few examples of progress to show, why couldn't they have Air Pollution Day and invite the citizens to a conference to discuss the problems and visit some of the plants where applications have been made to abate air pollution?

H. K. KUGEL. Dr. May spoke about the possibility of zoning for air pollution, setting upon certain areas in which different maximums and minimums for air pollution would be set up in order to protect both industry and residential areas. I would like to know if there are any cities or areas which have set up such zoning for air-pollution control.

Second, if such an area or areas are set up within a city or county, would that not be a case of one of those overriding authorities which might very well cause confusion with existing air-pollution authorities?

Third, Dr. May mentioned that in setting up such areas it might be desirable to set up different standards for air pollution in different areas, according to whether they were residential, light manufacturing, or heavy manufacturing, and so forth.

Thinking of it from an actual inspection and control standpoint, I wonder if he had thought whether such a procedure would be practical, whether it is possible to set up areas within a city where you would have different measures of control in effect.

Dr. MAY. First, I was asked where air-pollution regulations which vary by districts within a community have been established. In the county in which I was planning director, I worked with Mr. Linsky in developing some town zoning ordinances which included such variations in regulations by districts. In the heaviest industrial district the requirements were lower than in the light industrial district, which were, in turn, somewhat less stringent than they were in a special office-type district that we established, and the same regulations as in the office district were set up within residential districts. In other words, there were three districts with three general levels.

There are a number of communities in the country which have adopted zoning ordinances in recent years with what we call performance standards, including performance standards for air pollution. Anne Arundel County, in Maryland, right near Washington, is one. I believe the city of Louisville is another, and there were a number of others.

In proposing variations by zoning districts, I am not at all proposing any superagency. This is a different question from the question of having countywide or regional standards. I think this whole aspect of the discussion has been dealt with by Messrs. Cooper and Linsky. I am not proposing that at all, though I have no objection to it. I think it is a separate problem.

I am talking about local regulations for municipalities. Most of my remarks dealt with problems in large cities, and I also made a reference to the problem in a suburban area, municipalities and suburban areas then, which are continually developing industrial problems and which have to find ways to deal with them.

In this question of different regulations by districts I feel that there is a level of air pollution or cleanliness which we are aiming at. Let's establish that level high. This is what we would like to see in the community, we will say, what you, the experts, can describe to us as a condition which will be ideal. We have at a much lower level a condition which exists in a good many of our older plants, our worst conditions.

As I understand it, your air-pollution-control regulations in many of your communities are coming along at a new level in between, saying that this is a satisfactory level which we can achieve. It is not the optimum, but it is a realistic level. It is an achievable level, so we are going to set this and try to bring everybody up to this level as soon as possible.

Some we will make conform immediately, if there isn't great expense involved, and to others we will give a certain amount of time.

What I am saying, first, is that all new construction should not be made merely to conform to this intermediate level, but should have to conform to the top level right now, because we are ultimately aiming at that; and second, that in communities that cover large areas we can achieve this top level of performance in all the many zones where we have only residential, and particularly single-family, development, where there is no air-pollution problem to speak of, or only isolated cases. We can establish the highest level for those immediately.

And in other areas, where it is not so critical, we can relax the standard and hit your realistic standard, which will be satisfactory from the regional standpoint in terms of the diffusion of air pollution from these areas into other areas, and will bring industries within those areas up to that degree of "satisfactory." It will also let industry live in these areas and encourage them to be there, because, as we in zoning and you in air pollution know, there are a lot of scattered plants and air-pollution sources in residential areas which are really dangerous and are most critical problems. And those should be dealt with as quickly as possible.

That is why I am proposing a scheme of this sort which will deal with them as quickly as possible. That is what I am aiming at.

Jack R. Adams. As a mayor, I think you will agree that mayors don't want supergovernments set up. That is generally our policy. We don't want a lot of commissions and boards and that sort of thing. Anyone who knows me knows that I am definitely opposed to that.

The fact is that at the American Municipal Association meeting in St. Louis I circularized that meeting with a pamphlet on the supergovernment deal, these commissions and so on that are set up, with the result that, first thing you know, the public as a whole doesn't have much to say about what goes on. I believe that a lot of mayors share my attitude.

I also brought up the matter of the eight-State compact on sewage disposal and river pollution, the pollution of the Ohio River. What happened in that case was simply this: a lot of people got together.

They had ideas. I think the whole thing started at Cincinnati. They had these ideas, and they went out and sold these ideas to people in these several States, and then, instead of going to the Federal Government, they went to the several States with a definite proposal, and went to the legislatures in those States and said, "Will you buy this?"

Now it was necessary that these several State legislatures OK their particular packet. I think it is altogether different from the Federal Government saying, "This is what you are going to do, and you are going to take it and like it. If you don't do what we want you to do, if there is any money involved, you are not going to get the money." That is what happens with a lot of our funds.

On this eight-State compact, what we have tried to do in our headquarters area around Wheeling is to make it more or less possible for those people participating in it to agree to it. If they didn't want to join, and didn't want to agree to it, the individual States didn't have to get into it.

You can't let this fellow on this side of the river, because he happens to be in one State, neglect his job as far as air pollution is concerned. The fellow on the other side of the river does do his job, and, unless you have some regulation and agreement in there, you are not going to get anywhere.

I am not in favor of a supergovernment being set up, but you will have to get to some basis of agreement, whether at a high level or a low level. You are going to have to get some basis of agreement to start with to get the air pollution show on the road.

Dr. **Greenburg**. The presentation by Dr. Richard May and the subsequent discussion on his subject involves the question of zoning for air pollution. Some time ago, a group of consulting engineers—from Chicago, I believe—came to see us and brought to us the proposed zoning regulations for the city of Chicago, in which were incorporated certain requirements on air pollution. We found this document to be exceedingly complicated. Our own opinion was that it was quite unworkable, unrealistic, and unenforcible.

Anybody who has had any contact with this problem of air pollution knows that, in order to make a go of it, it cannot be too complicated. If it is complicated, it is self-defeating, and I think there is no question about this.

I believe that, consequently, this was not adopted by the city of Chicago. I believe they have adopted some air-pollution regulations now; whether or not their zoning regulations contain any air-pollution provisions I do not know, but I believe they do not or, if they contain any air-pollution requirements, they are very, very limited.

Subsequently, about 6 months ago, the chairman of city planning of the city of New York got in touch with us and said he would like to discuss this subject. We spent an evening at his home, and sometime subsequently at our office, discussing this problem and trying to see whether we could agree on some rational manner in which we thought air-pollution regulations could be compounded with zoning so as to do a better job.

Frankly, we did not find such a solution to the problem. I know of no practical solution to this problem as of this moment. I doubt very much whether the suggestion which Dr. May made, with two levels of air pollution—achievable level and preferential level—is logical. I do not know whether it is legal or whether it would stand testing in the courts. I do not know if it could be applied with a reasonable degree of accuracy by a control official. And certainly, if it weren't spelled out very accurately, the control official might very well find himself in deep water in his efforts to enforce it, and with perhaps many legal complications, too.

Basically, behind this whole question, I think you have to go back to a scheme that was proposed by the State of Massachusetts not long after the turn of the century. The State of Massachusetts proposed, in the control of atmospheric conditions in factories with reference to air pollutants and toxic materials, that the best known practical means, at any particular time, should be the requirement of the official agency.

Of course, there are some catchwords in this—"best known" and "practical," and so on. But it was on the basis of this rule that Massachusetts proceeded to clean up its industries.

Now, if there is a "best known practical means" of controlling the effluent from a plant, this is the means, and the only means, it seems to me, that the official agency can use as a guide. This does not permit two levels, an achievement level and a preference level, because the two would merge together into one level. It seems to me the only thing you can do under these conditions is to realize that air pollution travels a good distance. This we have all agreed on here today and at other prior meetings. And if this is so, it seems to me that it is quite impossible to draw a zoning line on a map and say that on one side of this line you are going to use an achievable level and on the other side you are going to use a preference level, because the pollutants from the two sides mingle together jolly well.

As of this moment, I do not know of any practical legal means of achieving a combination of air pollution regulations with zoning.

Dr. McCabe. In the early days of the Los Angeles district, when the mass rate regulation was put in regarding dust, it was designed to give the small operator somewhat of an advantage percentagewise on his requirements as to recovery of dust. The theory was that the small unit source was not as serious a problem as the large unit source.

For example, if the operator of a small foundry was operating on 200 pounds an hour, he might be required to have an 85-percent recovery of dust. Whereas a steel plant, operating on 6,000 pounds an hour or more, might be required to have 95 to 97 percent recovery.

We discussed that with Mr. Kennedy as to whether or not it was legal, and he said, "Well, the income tax is legal, isn't it?" It certainly operates differently for different people, depending on the size of their income. Based on that, Mr. Kennedy said we were legal, too, and so the mass rate tables were applied.

With regard to zoning, my own feeling is that it might very well be applied in areas where industrial building and residential building are starting. If you have a new, clean area to start with, obviously you have a much easier problem than you would have in a city like New York.

The British have applied this here and there in rebuilding the bombed-out cities. They have so-called smokeless zones in which they place certain activities that are not permitted to make smoke or exceed a certain level. Then they have a belt of trees and beyond that an industrial area, so they do zone to that extent.

Erwin E. Schultz. I would like Mr. Mommsen, director of air pollution control for Chicago, to answer the specific questions that have come up on the Chicago ordinance, in which zoning was proposed.

Fred T. Mommsen. Mr. Schultz and I are both from Chicago, and there has been considerable discussion about the Chicago zoning ordinance with the air-pollution standards incorporated in the zoning ordinance. In the original draft, air pollution-emission limits, shall we say, for particulate matter and smoke were to be incorporated at different levels in the zoning ordinance.

To avoid any duplication of jurisdiction, at the request of the air-pollution-control department these standards were removed from the proposed zoning ordinance. The zoning ordinance has been approved by the city council. It does not contain air-pollution provisions in it. I wanted to get that straight.

Mr. Schultz was one of the consultants who worked with the department and many other agencies in drafting a proposed ordinance which is before the city council at present.

Mr. Schultz. Dr. May's presentation is getting a good deal of attention this afternoon. One of the basic propositions involved in the performance standards type of zoning is the assumption that the performance standards contained in the zoning ordinance are, in Dr. May's words, economically and technologically feasible.

I am not a scientist, obviously, but I do know that when the ordinance was first presented to Chicago we asked what I considered to be some of the best brains in the United States on various subjects concerned—noise, heat, vibration, smoke, and other subjects—to examine these performance standards in detail. It was their considered judgment that the performance standards were not economically or technologically feasible.

We reached, then, the same conclusion that Dr. Greenburg reached when he looked at that ordinance and said that the performance standards were unworkable and unrealistic.

What we did next was go to those who had framed the performance standards and ask them to explain how those standards could be applied in a complicated urban area such as Chicago is.

The answer was that the performance standards themselves were designed primarily for new construction, in an ideally zoned area, so you would have industry separated a great distance from the residential, business, and commercial areas, which, in the jargon of the planners, are to be protected from the noxious and objectionable emissions of an industrial area.

With this admission from the framers of the proposed ordinance on the performance standards, and with their cooperation, we then sat down and worked out standards which may—and I use that word advisedly—be feasible, but we felt that we had to eliminate all air-pollution standards on the grounds that they don't fit, even under the broadest theory, into the entire performance standards zoning concept.

I would say this with respect to performance standards zoning; it is entirely new. There are a number of very competent men in the field who would question the economic and technologic feasibility of these standards, and we do not know, at this time, whether or not they will work.

I hesitate, therefore, to be enthusiastic about the idea of rezoning all of the major cities of the United States, using a concept which is not tested to the point where we know that we will get a desirable result.

In Chicago we have had the ordinance—and I think Chicago is the first example of this type of ordinance in a large metropolitan community—for about a year. We haven't the faintest idea whether the performance standard is working.

I wanted to make one other point about this, because we have here people from all over the United States. These performance standards were presumably tailor-made for an area like Chicago. Now, the original draft in 1955 received nationwide circulation. This draft, with these performance standards in toto, including the air-pollution performance standards, is now in the hands of local administrative officials throughout the United States. To date, I know personally of four communities which have adopted in toto the entire Chicago ordinance as originally drafted, despite the fact that in some areas, such as Du Page County, 95 percent of the area is farming.

So I would say that performance standards have a long way to go, the first step which has been taken is a long one, and I don't know where we are going to end up in this field.

Mr. DUTTON. With my compatriot, Dr. May, under fire on zoning, I would like to say some things that maybe he won't say and maybe he won't agree with entirely.

Possibly the focus is different from that I would like to see when it is suggested that zoning ordinances and the zoning power cannot be of assistance in the general air-pollution problem. I know a few planners who would be glad to turn it over to someone else—an air-pollution-control officer or someone else who had the technological skills and ability to deal with the problem or know when to leave it alone.

Traditionally, zoning has been that technique whereby we have been able to say we don't want an industry across the street. We don't want a filling station on the same corner that the mayor's house is on. We have gotten more sophisticated, as years have gone by, in trying to set up the proper land-use areas in communities.

Now, we know of some 20 communities in the country that have performance standards and, as in the case Mr. Schultz pointed out, they shouldn't have something which somebody else has already rejected.

But we have other kinds of situations, like Menlo Park, Calif., which has set up a highly restrictive performance standard arrangement, and I believe their mode of performance control for air pollution is to say there won't be any emission.

But that is too easy an answer for a place like Chicago or Chicago Heights, places where we have to have the heavier industry.

I think it is clear in the laws on zoning that we can set up a differential standard for new construction without having to bring up all existing construction to conform. Unfortunately, we haven't gone very far in zoning to make nonconforming uses eventually become conforming. That will come about probably as we become more accustomed to our urban way of life and keep trying to improve it.

A different point, I think, is applicable to the commissioner of the Department of Air Pollution Control, Dr. Greenburg, namely, the reasonable aspect of the limitation; that is where planners and zoning officials are concerned. How do we establish the reasonableness? Is there a series of criteria, as in water pollution? For example, the water flows by at a certain rate of speed and in so many cubic feet of water you can discharge so much waste and it won't pollute the stream for the man a little bit down stream that has to drink the water.

Can we improve our technology to the point that we know what kinds of emissions can be permitted under certain circumstances, and which can't?

I gather that in some areas this program has gone along so far.

Under our laws, we say how much land can be made available in communities for industrial development and how much for other development, and we do this to protect the health of the community.

We could also say that the use of the air is common to all, and determine to what extent the atmosphere should be used to carry away air pollutants, 5 or 50 percent, say, of its capacity for carrying it away, if we are forced to make that choice by the conditions in the area.

I agree with Mr. Sullivan's comment, that we want to keep these governmental controls in the hands of the people who vote. I spent 4 years in South Carolina and I don't have to apologize to anyone for having learned about States rights. But there hasn't been any focus in this discussion today on the problems that were identified in some of yesterday's speeches—the growth of population of this country by 1980; the type of megalopolis that will be formed; the kind of industrial soot we are getting; the percentage of our people that are living in industrialized and urbanized areas; and the fact that our urban groups are changing with changes in transportation facilities which, among other things, allow people to get in their cars and drive for 20 minutes trying to escape smoke haze. These are the people who move out from the jurisdiction of the various mayors but still are insisting on some kind of air-pollution control.

We, in our particular area of concern in planning, are beginning to worry about the atomic energy installations and the kind of pollution they will cause, and wondering whether our traditional units of government will be able to cope with those.

By way of defense of zoning and planners, I would like to say to the people who raised the question about our traditional forms of government that I don't think it is true that the cities came first and built the States. I think the reverse is true. We had the Colonies, and eventually urban government emerged and has been having a hard time ever since, getting the proper status within many of our State governments. In many situations we are relying still upon the State governments to show the leadership for this kind of problem.

When we get to the question of levels of government, I am often reminded of the battles in the conservation movement, where the people who showed up in Washington to say, "Let's keep States rights," were back in their State capitals fighting against actions being taken at the local level.

This problem is one we will have to live with and cooperate on. We should sit down together frequently to find out what resources we have in our administrative and technological structures to help us find some of the solutions.

Dr. Greenburg. On zoning and air-pollution regulations, I asked you this question: If old installations have to achieve a satisfactory level, why should a new plant be compelled to spend additional money to achieve a supersatisfactory level? I am in great sympathy with this idea in general, but how you are going to uphold this in court is more than I understand.

Mr. Linsky. In connection with the relationship between air pollution and zoning, I would like to point out that most communities have a zone in which a special use permit is required for certain lists of industries, usually spelled out by name. The zoning authority, usually the planning commission or, in some cases, the legislative body itself, the city council supervisory board, on the recommendation of the planning group spells out the performance characteristics of whatever will be allowed to go on a specific piece of property. What is generally known as a use permit in the West has other names elsewhere in the country.

The air-pollution-control agency or the air-pollution specialist, whether he is in a public agency or not, can provide and is increasingly being called upon to provide technical information to the planning or zoning authority.

If he does this properly, in my estimation, he says that with this kind of equipment on this kind of process you may expect this kind of result at this kind of a distance from this kind of operation in this neighborhood. This kind of thing is going on every week, almost every day, throughout the country. It has a slight relationship to the policy of performance standard zoning, but it operates completely outside of it.

Dr. May. I couldn't add to Mr. Dutton's summary of the planning profession's point of view and position on the matter, but I want to clarify a couple of points that have arisen since I spoke. First, as to the question of jurisdiction, we have absolutely no intention of impinging in any way upon the jurisdiction of the air-pollution-control agencies. We are not competent to do so. We have absolutely no intention of administering any regulations.

As I said this morning, I do feel we have some role to play in the drafting of such regulations. In fact, as Mr. Dutton said, we would be very happy to get out of this whole question and leave it to the air-pollution agencies if we didn't think there was a problem, but we do feel there is a problem.

When Dr. Greenburg discussed regulations in a particular district with relation to the activities within that district, he said that we can't expect certain activities or establishments to be able to conform to the regulations that we would like to propose in that district.

That is a very fundamental question to us, because it is our intention that those activities not be permitted in the district. It is just what we are striving for. That is the answer to the question. If they can't conform to the standard in the district, let them go to another district where they can conform to the regulations.

With regard to the technological and economic feasibility of the regulations, we did not draft those regulations. We, as planners, did not draft the regulations that have been proposed in the various zoning ordinances that we have worked on. We have come to this profession and to the acoustical engineers in the case of sound, and to the physicists in the case of radiation: we have gone to the various disciplines, to the experts in the fields concerned, and asked them to draft regulations along the general lines we had in mind, to meet the needs as we saw them and if they were not technologically nor economically feasible, then I am afraid we were misled.

If they are not—and I am willing to accept the fact that they are not, in many cases, economically and technologically feasible— I think that brings us to the point where we need to explore this field more and to develop regulations by research which are economical and technologically feasible, if they can be developed.

And, finally, if the level of performance which has been established in the various air-pollution regulations within our cities and regions and areas of jurisdiction is satisfactory, then we have nothing to dis- cuss, and there is no need of any variations by district.

Mr. Linsky. It is technically possible to operate anything as clean as you want it, if you have unlimited funds. The cleanest elements in some types of operations are still not compatible with, let us say, a fine residential neighborhood within 50 feet. You just have to think of some of the kinds of operations as clean as anyone has made them in the country; you know that is so.

The possibility of a vent valve releasing when there are hundreds of such valves or the possibility of a line breaking when there are hundreds of thousands of feet of process piping makes it obvious that there are some things that ought not to be close to some things, no matter how clean they are and how ably they are handled. You just don't put a hot asphalt batch mixing plant, no matter how clean it is, next door to an electronics precision machine shop.

If, instead of spelling out hot asphalt batch mixing plants, you spell out the gas loadings, the total rates of emission, this would be a nice thing to do. Then, if a hot asphalt batch mixing plant wanted to provide enclosed silo storage with dust collectors, complete air control in the truck loading, the highest degree of control on the drying kiln and on the mixers and the pug mills, and wanted to pay the price for it in exchange for getting closer to some area that he wanted to be in, then he should be allowed to spend that kind of money and locate in that area.

Some of us have been talking about transposing a specific proposal for an existing large mixed metropolitan community to another sim- ilar existing community, while others are thinking of new communi- ties that are developing practically from farmlands, that are able to design themselves a little bit better, the kind of place you and yours can have your home in when you can afford it and can afford to take the commuting time.

Ralph C. Pickard. Much has been said here about the eight- State compact which was formed on the Ohio River. As a represent- ative of Kentucky, one of the participating States, I feel that if I do not set the record straight here I will not be able to go back home and face my colleagues.

First, this compact was formed with the permission of the Federal Government, the Congress, and ratified by each of the States con- cerned. They were not forced in any manner to join this compact, but were invited to join it by ratification of their own State legis- latures.

Second, the results of the eight-State compact in water pollution speak for themselves. The accomplishments have been many. They have been made not only by the officials of the various States but also by industry and others, working on committees and advising and cooperating with compact personnel to get the job done.

Third, the injunction that was spoken of a few minutes ago was against a sanitation district, which is formed under a State law, and the plant was closed on the basis of an order of a circuit court judge, and not a State judge. I call your attention to that fact, that this is the first time in the history of my profession that a sewage-disposal-treatment plant has been closed on an odor basis by a circuit judge by injunction.

The Water Pollution Control Commission of the State of Kentucky intervened to keep that plant open to give it time to prove that it could be operated properly.

The interstate commission, the Ohio River Valley Water Pollution Control Commission, has not been in on this so far, because it is a water-pollution-control agency and not an air-pollution-control agency, and they have not been called on.

Thomas M. Drake. I know very little about air pollution, but I am a political scientist by profession, and should know something about government.

Interstate compacts are the only means whereby States can make constitutional agreements with one another. Since I know very little about air pollution, I cannot advocate the usage of interstate compact to solve air-pollution problems. By this I mean I cannot say that this is a certain solution to the problem of air pollution.

I recognize, however, that air pollution transcends political boundaries. The interstate compact has proved, time and again, a successful means whereby interstate problems of transportation, sewage disposal, and water pollution have been alleviated. These successes have been well documented, and the proof is available.

If a choice should have to be made between the exercise of constitutional power by the Congress of the United States under the commerce clause, or by particular States under the compact clause, I would give serious consideration to the possibility of entering into an effective compact.

"Supergovernments" or "superagencies" is no proper way to describe agencies established under interstate compacts. They are, as Mayor Adams and Mr. Pickard just pointed out, entered into by State legislatures. An explicit act of approval, it is true, is not necessary from Congress. Congress may give its assent by silence, or Congress may explicitly disapprove, as they have done on occasion, of a proposed compact.

Compacts, therefore, are approved by the legislatures of the States entering into the compacts—legislatures elected by the people of the particular States. Compacts are approved by the Congress of the United States, either implicitly or explicitly.

No agreements made anywhere are potentially more subject to careful scrutiny than are compacts. A compact does not create a superagency; it is merely a constitutional means whereby States can get together and work out their mutual difficulties.

From what I have heard today and yesterday, I assume that at least certain States have mutual difficulties concerning air pollution. I do not feel that a blanket condemnation of the compact as a means of providing some solution to the air-pollution problem is justified, and specifically I suggest that the experience of agencies operating under compacts should be carefully considered before the utility of compacts, as a means of clearing the air, so to speak, is discounted.

Joseph J. Weinstein. My problem is a relatively simple one compared to what has been discussed here now. I feel like an outsider, in a way, because we in Phoenix, Ariz., compare very unfavorably in terms of the severity of air-pollution problems with the large communities around the United States.

But we are very sensitive to matters pertaining to air pollution. We are only about 1 hour's flight from San Diego and Los Angeles, and we don't get very far up in the air before we see the billowing smoke moving over the mountains in our direction. We worry about this, and we meet and talk about it, and we would like to set up some sort of a program in anticipation of the possibility that we, too, may one day have such a problem.

I would like to know from the panel at what point—assuming that our air is relatively clear now, even though we have particulate matter in the air, as we would in any desert country—ought we to be so excited about this that we would begin to set up boards, make tests, or install equipment, or ask the Public Health Service or other agencies to assist us and to advise us.

Dr. McCabe. The time you begin to ask the question is the time you should start working on measuring the air. You need a background, even if you don't have any contamination now. Every air-pollution-control officer feels that if he had levels on the air 5 years before he began to work on the problem he would be in a better position. To show accomplishment he has to measure things. I would start with the minimum of air-pollution measurement, if nothing else, with the high-volume sampler that the Public Health Service has established here and there over the country. Do you have that now?

Mr. Weinstein. Yes. We are on the national air-sampling network.

Dr. McCabe. Then that is the minimum you ought to do.

Mr. Linsky. That problem has become apparent. I am sorry John Maga, of the California State Department of Health, is not here. He is the chief of the bureau of air sanitation there. They have no control authority. They are an aid and support group. The same problem has been developing in California; it is a parallel situation, particularly over in the Central Valley. Eight or ten years ago, San Francisco was sending those joke cans of pure air to Los Angeles. Sacramento and Stockton began about 2 years ago sending joke cans of pure air into San Francisco in the bay area. But in the last 2 years, both Stockton and Sacramento, which considered themselves somewhat like your community for many years, learned that they had already passed the threshold of important detection, the first indicater being vegetation damage from the western-type smogs.

I would suggest to you, in addition to the high-volume samplers which will give you some characteristics of your particles, that, on examination of the effects by some of your skilled State and local vegetation experts, your agricultural people can tell you when you get your first vegetation damage, and this is a very good indicator.

As it happened, at first, the feeling in Stockton and Sacramento was that the stuff was blowing over from the bay area. A more careful examination showed that more than 90 percent was self-generated in the immediate communities.

So they are now doing their community organization and study work for program development, ordinance design, et cetera. But the sensitive detector, which is vegetation, is a good indication for the kind of air pollution that, apparently, you are worried about.

I agree with Dr. McCabe that the time is now to get a baseline—to make certain by an expert survey that you haven't exceeded your thresholds, and then as you look periodically, possibly once a year, you will find when you need to go into an action program that may be based on your own locally generated materials. If your action is pointed at incoming stuff from other areas outside of your jurisdiction, this means that you have to look to the county or State or interstate compact, or whatever else might be indicated.

Dr. McCabe. I think we have covered the area, generally, very well, that has been laid down for us through the papers and questions raised, except the third question: "What place should concern for health have in an air-pollution program?"

At first glance you would think the answer is quite obvious, but I have been concerned in my work in the air-pollution field that we quite often attribute to air pollution health effects for which we have no definite proof. Every air-pollution officer undoubtedly wishes he had more definite standards of evaluation of health, as far as air pollution is concerned. It would help him materially in his enforcement program if he did have definite standards or maximum allowable concentrations.

It is a significant question, I think, because, regardless of the fact that we don't have those standards, we still come back and talk a great deal about it and we attribute the need for air-pollution control to health reasons. The Surgeon General said yesterday that we need not wait for definite proof of effect on health to clear up the atmospheric pollution problems.

I quite agree with that. However, I do feel that there is a tendency, as we go along, to attribute health effects to certain specific contaminants when that contaminant may not be the culprit at all. It may be another series of contaminants, if there is a health effect, and I do feel we should use some caution in the approach in attributing health effects to a specific contaminant, which may not actually exist as a health hazard.

Dennis J. Sullivan. As a person charged with the administration of public health laws, I believe that a health officer is on dangerous ground when he attempts to go to court or to try to prosecute someone or take action with respect to a certain situation on the basis of its affecting someone's health.

When we think of our knowledge of certain substances and the tolerances permitted during an 8-hour day in an industry, and then think of what a person may be exposed to during a whole 24-hour period outside, we would, from an administrative point of view, get ourselves on very dangerous ground. And I think, in connection with the various statements that have been made here, either by inference or otherwise, as to the possible effects of these various air pollutants upon a person's health, that you are certainly on safer ground if you attack it from a nuisance standpoint rather than from the effect upon a person's health.

In many areas the ordinances are written so that, while there is a reference to the effect upon health, there is also a reference to the right of a person to the use and the peace and comfort of his home. The courts, I know, have accepted that. In our case, where we have had to take legal action against someone who has been polluting the air, we have done it on a nuisance basis and that has stood up in court. I just offer that as a word of caution for anyone who has to administer ordinances or State laws to keep in mind.

Mr. LANSKY. The single word "health" or "health basis" for air-pollution control is a little bit too "bushel baskety." You have to break it up a little bit. The phrase which appears in most State and county and special district references is "public health and welfare" and it was on that basis that my list of eight points was compiled.

Visibility interference—the loss of view—is a matter of enjoyment of property. It has a secondary effect in interference with services when you exceed the restriction in visibility in the abyss of fog; when your visibility is below 3 miles, you fly instrument or you don't fly. Visibility interference also means the loss of a view. Spoiling a view—for example, the beauteous bay area—is insupportable, obviously. Even the cash value of a view window is something around $10 to $20 a month in rental values.

Sky darkening—the loss of sunlight—is a result of flumes overhead. It doesn't happen to be a western problem, but it has in the past been an eastern problem.

The soiling of surfaces—light or dark—this is an impediment in the use of property. You have to launder or wash or clean more frequently.

Annoyance to senses—by eye irritation or throat tickle or malodor sensation—these are real. They are very obviously in the nuisance-phrase category.

Damage to vegetation is actually damage to property. This, under public welfare—the welfare part of "public health and welfare"—is obvious.

Other property damage—by corrosion, abrasion, and similar effects—is another welfare factor under the public health and welfare clause.

Interference with production, where what comes out of one operation messes up another operation, is another one of the factors on the welfare side of public health and welfare.

Impairment of health was phrased very carefully. Outside of the disaster situations of the Donora, London, Meuse Valley, and Poza Rica, I know of only two situations where there was valid medical authority in writing for the impairment of health by air pollution. One is berylliosis in a community, and the other is based on a ruling in the city of Detroit, where the office of the commissioner of health officially stated that the smoke from the burning of leaves is detrimental to the health of a person with asthma, living nearby. There is a third situation which relates to the second, but I have never seen it in writing in just that way. Those of you who have ever been caught, or have had someone in your family caught, in the plume of a burning pile of poison ivy brush or poison oak or poison sumac know that this is a localized impairment-of-health effect. I have never seen it said that way by a medical authority, but I think it would not be difficult to get that kind of verification.

Those are, as we understand them, our bases for operating under "public health and welfare" with respect to air pollution at the present time.

William T. Ingram. To indulge in a little philosophical discussion of this particular problem, sanitary engineers, in their entire professional career, are trained to think of the development of an environment that is suitable for man. The elements of an environment, for purposes of discussion here, are composed of the air, the water, the food, the shelter, and the waste products, because men live in that environment.

These are all rather well mixed up in the sanitary engineer's concept of what must be done, and the question of whether or not people are going to live or die because something is not done is not the most important consideration.

The environment that people are entitled to is an environment that is good, that is clean, that is healthy, that is satisfactory from the standpoint of people's needs, and what satisfies some people in one case is not necessarily the same environment that satisfies other people in another case.

Now there are degrees and levels of this environment which are then obtained. One basic level is that of absolute survival, and obviously no one wants to live in a situation, nor can they live in a situation, in which the oxygen is depleted and they are about to be asphyxiated.

The next level is that of prevention of disease. The question of whether or not there are diseases or toxic effects that are affecting the health which may cause death or permanent injury is open to question.

The level above that is a matter of engineering efficiency, of supplying the necessary services, the necessary environment to satisfy the needs of people living on a community basis.

And the last level is sort of whipped cream on the cake, which is a matter dealing with the ultimate in comfort for people as they would like to live—in the plush-plush!

We have all levels of such environment in various phases of operation in the United States. And when you analyze it very carefully, there is only a flick of the wrist, so to speak, separating the survival level and the plush-plush level, because certain situations can change overnight which will introduce conditions of real disaster level or survival level, where there was not even a thought of it before.

And on this basis, I suggest to you that there is some real reason for everybody everywhere doing something about the air-pollution problem. What that something will be is contingent entirely on what the needs of a particular community are. And if these are a matter of getting background levels, as is possibly the case in Phoenix, Ariz., that is the thing that should be done. Knowing what the problem is as of today, if it is a case of doing something in the way of stringent action, as was the case in Donora, then that is the thing that should be done.

But the point I am really coming to now is this: We are talking about a resource which is ours and which we should preserve. I happen to be serving as chairman of a committee of the sanitary engineering division of the American Society of Civil Engineers, and our whole committee report, which is going to be quite a comprehensive one and should be released within a year, deals with the engineering management of the air resource, on the basis that this is as much something that should be looked at with all of the engineering concepts and all of the engineering skills, as the water resource has been looked at in the past, and as people are looking at housing and all other activities that affect people.

And I think, if we look at air and its preservation as a resource from the standpoint of the engineering management of that resource, we can achieve a better rationale than if we try to push for an objective which is a flashpoint, perhaps, or something that is going to get more money in the pocket or arouse people to action of one sort or another, which may last for 5 minutes or 5 hours or 5 days, depending on the situation.

The good rationale is to consider the air as a resource which we must preserve and care for. If we can use it for the disposal of waste, let us use it, but let us use it intelligently. If we must remove certain things from the air in order to preserve the constituents of the air so people may use them properly, then let us do that. But let us do it on the basis of a rationale of good engineering concepts, of good analysis, of good measurements, of good analytical data which are the baseline of action.

Third Day

PLENARY SESSIONS

Morning Session—Thursday, November 20

Chairman
Mark D. Hollis
Chief Engineer, Public Health Service
U.S. Department of Health, Education, and Welfare

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REPORTS AND RECOMMENDATIONS OF DISCUSSION GROUPS

Discussion Group "A"— Extent of Air Pollution

I. (a) *Where do we stand in our knowledge of the identity and quantity of pollutants in community atmospheres?*

This question is concerned with our ability to apply quantitative measures to pollutants in the atmosphere, rather than to how effectively this ability has been applied to measurements across the Nation. The group of discussants devoted their principal attention to problems concerned with manmade pollutants of a chemical nature rather than with airborne bacteria, pollens, and similar viable pollutants of natural origin. They recognize, however, that these latter pose important problems that need further consideration.

In identifying and measuring general classes of manmade pollutants, knowledge and techniques are available for studying almost any situation which has been found to occur. However, in identifying and measuring the individual substances which go to make up these classes, we are not nearly so fortunate. For example, the total amount of solid material in the atmosphere can be measured in any of several ways. But when it comes to measuring certain specific compounds, means of positive identification are still lacking. Even for the partial identification which is now possible, the procedures are tedious and expensive, and only a few laboratories in the country are equipped to undertake such a task.

Most of the measurement techniques for identifying trace quantities were originally developed for industrial hygiene use, where concentrations on the order of a few parts per million were being measured. Now, in studying community air-pollution problems, concentrations in the parts per billion range must be measured.

For a large number of substances, methods have been developed to obtain quantitative results from samples taken for periods of 24 hours or longer. For a small number of the more simple gases such as sulfur dioxide, hydrogen sulfide, and carbon monoxide, for example, methods are available to show the concentration minute by minute. Among the substances which can be measured over longer time intervals, but which we would like to measure minute by minute, are aldehydes, olefins, polynuclear aromatic compounds, and some particular industrial effluents. Since concentration-time relationships are not well understood, studies for a number of different averaging times will have to be made until the relationship becomes clarified.

Another disadvantage in applying available methods is the matter of cost. Many of the instruments which are now available cost several thousand dollars apiece, which limits their application to situations where the information is urgently needed. Along with the development of new methods of atmospheric measurement, there is great need to make these methods commercially available at lower cost so that they can be more widely applied. Because of the recent history of the development and application of measuring devices, we have become accustomed to thinking in terms of elaborate devices, to the neglect of simple procedures such as impregnated test papers and other straightforward methods. Such techniques as film badges for workers handling radioactive materials, and the indicator crayon used by military forces to measure exposure to toxic gases, could be extended to provide techniques for air-pollution investigations. These techniques are all averaging techniques; similar methods responsive to peak concentrations are also needed. These might eventually be used in warning systems.

Most of the methods now in use have been adaptations of methods originally developed for other applications, and borrowed for use in air-pollution-research studies. Incentives need to be provided for the development of methods specific to the needs of air pollution. Special attention is drawn to gas chromatography as a separation technique, supported by infrared absorption and mass spectrography for identification purposes.

Even though our ability to identify and measure pollutants is not as far advanced as we believe it should be, it is much further along than our knowledge of the significance of these measurements as they affect the health and comfort of man.

I. (b) *Where do we stand in our knowledge of the trend in change of such pollutants and their pattern of distribution?*

The only pollutant for which we have a sufficiently long record of measurement to establish trend is settleable solids. For this pollutant, we know that there was a consistent downward trend for several decades, which has recently flattened out. Sulfur dioxide has been measured for over 20 years in a number of locations, but the results are not available to the public. Fluoride measurements have also been made for over 10 years, but the results are likewise unavailable.

Other than these three pollutants, none has been systematically measured for over 10 years. The longest record for pollutants, other than fallout, sulfur dioxide, and fluorides, is that of the Los Angeles County Air Pollution Control District, where continuous measurement has been made since 1953 of oxidant. Systematic, continuous measurement of carbon monoxide and oxides of nitrogen was started in 1955, when the "alert" system was established.

Analyses of suspended particulate matter by the National Air Sampling Network of the Public Health Service were started on a small scale in 1953; however, for most communities associated with the network, the starting date is January 1, 1957.

Direct measurements of soiling have been available for several years and are of considerable use in determining progress made in air pollution control.

Thus, it is apparent that long-term trends cannot be established by the data available to the public, for other than settleable solids and soiling index.

A recent survey of the location of continuous, automatic measuring devices for gaseous pollutants showed that 100 of these devices were located in California, 48 were scattered throughout the country in the hands of industrial organizations, and 10 were operated by public agencies outside of the State of California. Thus, it is obvious that data to indicate trends of gaseous pollutants are primarily confined to California. A true national picture of the distribution of suspended particulates has been obtained during the past 2 years by the National Air Sampling Network. This network has the limitation of affording only one sampling site in each community and therefore can at best only indicate the general level and type of contamination in the community.

The available measurements of settleable solids and soiling index are primarily from large eastern cities where coal is in widespread use as fuel. Outside of the coal-burning areas, there has not been the public demand for abatement which would lead to the continuous, systematic measurement of gritty and grimy materials in the atmosphere.

The available data show that definite correlations can be established between the type and amount of pollution and such factors as the size of a city, the type of fuel used, types of industry present, common methods of transportation, and other factors related to the patterns of our modern civilization.

I. (c) *Where do we stand in our knowledge of the specific effects of various topographic and meteorological conditions and of concentration or dispersal of sources on the concentrations of such pollutants?*

Some knowledge has been available for many years concerning the diffusion phenomena which control the dispersion of pollutants from a point source. Originally developed because of military interest in the spread of a cloud of a toxic agent, this knowledge was later applied to studies of industrial emissions from a single stack. Early in this work, the effects of varying meteorological conditions became evident. One of the most exhaustive studies of pollutants from a point source was completed at Trail, British Columbia, where a complicated meteorological and topographic situation caused widespread pollution throughout an entire valley at certain times. A complete understanding of this situation was necessary before suitable control measures could be developed. The importance of the meteorological phenomenon known as inversion in affecting air-pollution situations was first brought to the public's attention as a result of this investigation.

The application of point-source theory to communitywide problems involving multiple sources necessitates a complicated mathematical treatment which is only beginning to be explored. Meteorological measurements at ground level are frequently not sufficient for this purpose, and measurements above ground level are usually even less available. The relationships between meteorology and topography have been under study by meteorologists for many years, and are quite well understood for general flow patterns but not for dispersion of contaminants.

When a combination of unfavorable meteorological and topographic conditions cause air to become stagnant over a community, the possibility is greatly increased that reactions will occur in the atmosphere to produce substances radically different from the materials which were originally emitted. Many of these reactions are not completely understood.

One influence on the concentration of air pollutants may be the dispersal of sources. By applying general principles already known, sources of pollution can often be located relative to prevailing winds and other sources so that adverse effects on the surrounding community can be minimized. In other cases, lack of knowledge concerning a particularly complicated meteorological picture makes proper selection of source location difficult. In still other cases, where winds are extremely light and variable, little can be done from the standpoint of source location.

II. *What, if anything, should be done further on these matters, and by whom?*

In identifying and measuring pollutants:

1. Effort needs to be expended in development of refined analytical techniques, to identify and measure pollutants which cannot be adequately measured at the present time in the parts-per-billion range.
2. More inexpensive methods are needed for continuous monitoring.
3. When monitoring pollutants, peak values as well as average concentrations should be determined until relationships are clarified.

In studying trends in change of pollution levels and their pattern of distribution:

1. Particulate sampling, as being done by the national network, should be continued to study long-term trends.
2. Gas sampling should be initiated to study the distribution of gaseous pollutants throughout the Nation and to establish long-term trends.
3. A national network based on only one sampling site per community is inadequate to determine the distribution of pollutants within any but the smallest communities. This points up the need for the maintenance of monitoring programs conducted by local communities at locations sufficient to define the local problem. This more intensive local sampling should be conducted in such a manner that results can be compared with other communities and with the national network results.
4. Much useful information could be obtained with little additional work if the results of previous unpublished sampling could be made available.
5. Monitoring programs should be reappraised at regular intervals to be sure that they remain dynamic in character and do not become self-perpetuating.

Concerning the effects of meteorology and topography:

1. Existing meteorological knowledge is not being used adequately for the solution of community air-pollution problems. Communities should be shown how they can measure and use meteorological data inexpensively and conveniently.
2. Systems of meteorological measurement specific to the needs of air-pollution investigations are needed. Most of the present meteorological measurements and observations were established to meet the needs of agriculture, aviation, etc., and do not provide the optimum service to air-pollution investigations.

3. Better methods are needed to relate emission concentrations to atmospheric concentration, more particularly for area sources such as cities. Theoretical and experimental studies are urgently required, not only of diffusion at distances of 1 mile and beyond, but also of the rate of natural cleansing of contaminant gases and particulates from the atmosphere by the processes of washout, rainout, gravitational settling, and turbulent impaction.

4. A better delineation of the air-pollution factors responsible for decrease of visibility is needed.

5. There is a need for better and more sensitive tracer techniques, with particular reference to the problems of tracing air movements within an urban area.

6. Recognizing that each community has a limit to the amount of pollution its atmosphere can accept, there is need for more knowledge of the interrelationships between meteorological and topographical factors for the establishment of these limits both for short- and long-time periods.

7. Atmospheric contaminants such as CO_2 which may be causing long-period changes in our climate should be monitored on a national basis at appropriate stations.

In historical perspective, the first measurements of air pollution were supported by local governmental agencies. Industrial organizations responded to these initial efforts by initiating studies in their own laboratories and by supporting studies in educational and research institutions. With the advent of the Los Angeles problem, and the organization of air-pollution control there on a countywide basis, major research support for a considerable period of time became a county responsibility, later to be supported by State-sponsored efforts in California. In recognition of the fact that the problem of air pollution extended beyond the confines of California, Federal support of research was sought and initiated. This federally supported research has been conducted directly in Federal laboratories, by contract with research organizations, and by grants to individual researchers. A mechanism has also been developed in California through the establishment of a private foundation whereby funds from industrial sources are made available to support research in private research organizations. It is apparent that there is no one best agency to support research, and no one best type of research organization to conduct this research. In our future planning, all methods of obtaining support must be tapped, both private and at all levels of government. All available research facilities need to be used in the areas of their greatest competence, depending mainly on where competent individual researchers and suitable facilities are to be found. There is a definite need for recruitment and training of additional qualified persons to meet the challenge of modern air-pollution problems.

Dr. Arie J. Haagen-Smit, *Chairman.*
Dr. Herbert C. McKee, *Vice Chairman.*
Arthur C. Stern, *PHS Resource.*

Discussion Group "B"—
Sources of Air Pollution

The speakers and members of Discussion Group B—"Sources of Air Pollution," met in accordance with the program for the National Conference on Air Pollution. As their chairman, I have the honor to present the results of our discussions.

Our most important program of speakers delivered nine papers, in the course of which various sources of air pollution were discussed; but let me say here that it was not possible, due to shortage of time, to attempt an all-inclusive coverage of possible sources.

As the printed program indicates, the items covered specifically were as follows:

Domestic and municipal sources.
Industrial sources, such as:
  Petroleum refining.
  Electric power generation.
  Metallurgical processes.
  Chemical processes.
Automotive vehicles.

The pollutants which were discussed represented in general the end products of combustion, the products of incomplete combustion, and the emissions of various kinds from process industries. Where quantities of pollutants were known or available, they were reported by the authors, and it is unnecessary to repeat this information here. However, it was discovered that information on the types as well as the quantities of pollutants was not known for all sources, and that many gaps in this information exist, largely because of the lack of analytical and test procedures. The panel dealt principally with primary sources of pollution, but it was recognized that secondary pollutants may result from reactions in the atmosphere.

Information on the quantities and types of emissions is basic to the problem of control. This information establishes quantitative objectives for control and identifies substances which are known to affect health, damage property, or create nuisance.

In any locality, the significance of any single pollutant or group of pollutants will depend upon the amount, the topography, the meteorology, and the number of sources involved, as well as the density of the population in the vicinity. Each community is a specialized problem and the pollutants which may be of concern to one geographical area will not necessarily be a problem to another.

There is a need for determining the relationship between the emission rate of a specific pollutant and its effect on the environment. It is desirable to establish tolerance thresholds with respect to effects on health, growing plants and animals, and the creation of nuisances.

The history of technology suggests very strongly that patterns of emission from all sources will change in the future. An example of this is the substitution of nuclear energy for fossil fuels in the production of power. Similarly, technological development continually alters the types of emissions from chemical processing and manufacturing. The precise direction in which these changes will occur cannot be predicted, but the fact that they will occur is certain, emphasizing the need for continuing source appraisals.

The rapid development of urban areas makes the significance of future increases in pollutants particularly important since greater numbers of persons will be exposed to the effluents from these sources.

The opinion was expressed by many speakers that neither knowledge of types of pollutants at their sources nor present methods of analysis is adequate. It was pointed out that in some areas the methods of identifying pollutants are not specific enough. Furthermore, in certain cases where methods are known, they are either too expensive or too time consuming, or both, and adequate methods for identifying minute quantities of pollutants are not readily available. We believe that there exists a need for knowledge and information on more specific, accurate, less time consuming, and less expensive methods for evaluating pollution sources.

In addition, there exists a need for a systematic compilation of available information on emissions from all sources, as well as a means for improved communication and dissemination of this information as it is developed.

We do not believe that the development of these improvements is the sole responsibility of any one agency, group, or individual, but that what is needed is the coordination of the efforts of all groups who are interested in this problem. By this we mean that industry and manufacturers of equipment have a responsibility for establishing information on emissions from their processes and devices; that research organizations should be encouraged to contribute significantly in this field; and that communities should develop information relative to their pollutant sources.

There is a need to make generally available information on sources of pollution and to analyze these data in order to avoid unnecessary duplication and to serve as a guide to others investigating these and related problems. In this regard we believe that it is necessary and proper that the activities of the Public Health Service in the dissemination of this type of information be expanded and continued on a permanent basis.

It is the consensus of our group that no time should be lost in carrying out the suggestions made herein. The rapid growth of the population and of the national economy, and the attendant increase in the quantities of pollution from all sources, indicates the need for immediate action.

In conclusion, members of group B recommend that the Public Health Service implement the following program at the earliest possible date:

1. Intensive development of instrumentation for source analysis.
2. The provision for training of specialized personnel in source studies.
3. The encouragement of communities to assess continually the sources of pollution within their boundaries, with technical assistance from the Public Health Service if requested.
4. The systematic collection, analysis, and dissemination of information on emissions from all sources in cooperation with local communities.

Sylvan L. Hanauer, *Chairman.*
Dr. Leslie A. Chambers, *Vice Chairman.*
Dr. August T. Rossano, *PHS Resource.*

Discussion Group "C"— Health Effects of Air Pollution

Concern about the actual and potential threat to health of atmospheric pollution has run through most of this conference. Several aspects of the health problem were noted by Dr. Burney in his opening remarks. Further references were made in various ways by Dr. Hilleboe, by Senator Kuchel, and by Dr. Leake in their remarks at the opening session. In this discussion of "What does air pollution do to humans?" Dr. Dixon summarized the current knowledge of the relation of atmospheric pollution to health.

From this general overview, group "C" at yesterday's day-long session probed somewhat deeper into the problem. Our 200 participants devoted the 4-hour morning session to a look at general and several specific aspects of the health effects of air pollution.

Mentioned in the first plenary session were several acute air-pollution episodes. Our group analyzed in somewhat more detail these acute episodes and lessons to be learned from them. In medicine we often refer to subclinical disease. Along with the specific Donora and London episodes, consideration was given to other incidents that approached the level of clinical recognition.

In future years such events may well be recognized as acute episodes of lesser intensity when our observation acumen is sufficiently sharpened. Possible approaches to more scientifically and accurately studying these incidents were noted.

Also mentioned to you on Tuesday were possible chronic disease entities that might be attributed to long time and repeated exposure to low concentrations of air pollutants. Group "C" paid particular attention to this matter. Laborious epidemiologic studies were described which are essential to the elucidation of the role of polluted air in the causation of chronic diseases. Particular attention was paid to chronic bronchitis, asthma, emphysema, cardiac and circulatory diseases, and to cancer. There was some probing into the intricacies of the anatomical and physiological changes in the lungs and other organ systems resulting from exposure to atmospheric pollutants.

From this 4-hour session a number of generalizations seemed to come forth to those of us who participated. Much knowledge about the medical effects of polluted air is already available. Many potentially important and significant leads have been uncovered. The body of knowledge is increasing in many directions and at an accelerating rate. I, for one, was heartened by the evidence of progress. I'm sure that as each of you studies the reports we heard yesterday, you also will catch a glimpse of the horizons ahead through the gradually dissipating smog of the unknowns.

I cannot resist stating to you that over 95 percent of our participants stayed with us right up to the 1:00 p.m. adjournment of the morning session, so intense was the interest in the presentations.

In the afternoon, group "C" divided into six discussion groups. The objective was for each group to consider specific questions that had been propounded by the Inquiries Committee. It was understood that the groups could go beyond the specific questions. At the end of the afternoon we reassembled and listened to the reports from each of the six groups.

In the time available, I cannot give you their complete reports but will attempt to summarize the conclusions and recommendations. There were several general recommendations that came in one form or another from several of the groups.

1. There seemed no question but that the national air-pollution program should be continued and expanded.

2. In the continuance of the program it was emphasized that problems in air pollution will be with us indefinitely, so the specific enabling law should have no specified terminal date. As one group stated, there should be "permanent extension of Public Law 159."

3. It was recommended that placing a legal ceiling on appropriations was unrealistic; budgets should be considered annually by the Congress on a basis of current program needs and potentials for effectively utilizing the funds.

4. It was concluded that since there are many unanswered health questions there should be acceleration of research on the health effects of air pollution. In such an accelerated program there should be participation by all agencies such as official health agencies, research organizations, universities, and industries, including the automobile industry.

In this regard it was emphasized that there are existing research potentials that, for lack of funds, are not being utilized.

5. It was recognized that intensification of control efforts should not and cannot await the definitive answers to many of the medical problems. However, there was agreement that it is imperative that such answers be found at the earliest possible time since they will serve to better guide the development and design of control programs.

6. From one group came agreement that nuisance due to air pollution should be regarded as a public health problem. Among the reasons noted were the effects upon efficiency and upon emotional and physical comfort and well-being. It was felt these effects need not necessarily be manifestations of specific disease entities.

7. One group specifically considered the responsibility of the voluntary health agency in the air-pollution field. In summary, it was concluded that such agencies should participate in promoting air-pollution control, in promoting and sponsoring health research, in supporting official agencies, and in an educational capacity.

8. Another group paid particular attention to the responsibility of practicing physicians and recommended that: first, organized medicine, through national, State, and local medical societies, should collect and disseminate air-pollution information to its membership; second, that the proceedings of this conference be made available to physicians and public health authorities; and third, that private physicians individually should be encouraged to use local facilities and services, such as those of local health departments or air-pollution control authorities, to assist them in the management of clinical problems that may involve air

pollution. Physicians should also serve as interpreters of the health aspects of the problem to their patients and to others in the community.

9. The question of "How would you estimate the impact of air pollution on your community health?" was considered by another group. Mentioned were eye irritation, irritation to the respiratory tract, and adverse influence upon emotional well-being, including anxiety about the possible hazard to health. They noted that because of incomplete information on the health effects of air pollution, community hysteria may develop which, among other things, may lead to unnecessarily restrictive laws.

10. Still another group considered the question of what should be the responsibility of Government—Federal, State, and local—in the determination of the health effects of air pollution. It was concluded that the current plan of cooperation among the three levels of government is effective and should be continued. In this instance I should like to quote the complete statement of the subgroup: "There was general consensus that the information on health effects of air pollution which is available was grossly inadequate as a basis for sound, nondiscriminatory legislation to effectuate control."

In discussing the role of Government, there was no intent to imply that the responsibility was Government's alone, but that, indirectly, research groups, academic institutions, as well as other groups, do have a share in the responsibility of determining the health effects of air pollution.

There was developed a set of recommendations designed to offset the lack of information on health effects and to delineate major responsibilities of the several levels of government:

1. In general, air-pollution problems *common to the country as a whole* should be the responsibility of governmental agencies at all levels.

2. Problems more local in nature should be the primary responsibility of the pertinent area, but consultative advice and guidance should be available and sought from State and Federal agencies.

3. Emphasis was given to an integrated team approach to the determination of the health effects of air pollution to provide efficient correlative data. Such a team approach would entail the collection of concurrent medical, epidemiologic, and aerometric data.

4 It was felt that local resources were not being utilized adequately and that additional useful medical statistics could be secured within the framework of well organized data collection programs involving the local health resources and facilities, such as health departments, registrars of vital statistics, practicing physicians, and hospitals.

5. Although more could be done with existing facilities, it was felt that an adequate program at the local level in most instances would require augmented financial support and intensive stimulation of interest.

6. As such significant health effects data become available, every effort should be made by the Federal agencies to disseminate such information to the States and, similarly, by States to local agencies.

7. Since adequate methodology in determination of health effects and sufficient competent personnel were not yet available, it was felt that a crash program for definition of health effects was certainly not indicated at this time. In this regard, there should be promoted, instead, an orderly but aggressive program of research in this area.

In conclusion, may I say this report reflects only a sample of the many important problems considered by group "C." I do want to express my deep appreciation for the contributions made by the many participants, the Public Health Service staff, and, particularly, Dr. Harry Heimann. It has been an honor to serve as chairman of such an illustrious group.

Dr. Malcolm H. Merrill, *Chairman.*
Dr. James P. Dixon, *Vice Chairman.*
Dr. Harry Heimann, *PHS Resource.*

Discussion Group "D"— Economic and Social Effects of Air Pollution

EDUCATION

We recommend a continuing and intensified education program in the following four areas:

1. The education of personnel so that the problems of the future can be met and solved.
2. The education of industry by the dissemination of existing information as to industry's obligation for air-pollution abatement.
3. The education of, and assistance for, public officials in meeting local problems of air pollution.
4. The education of the general public in its obligations in controlling its own contribution to air-pollution problems.

RESEARCH

The following areas need study:

1. The effect of air pollution upon organisms and materials.
2. Extent and cost of air pollution in our economy and society.
3. Extent and cost of air-pollution control in our economy and society.
4. Research into administration and legal techniques of air-pollution control.
5. Research on sociological implications of air pollution and air-pollution abatement.
6. Research and development of new and less costly air-pollution-control techniques.
7. The encouragement of research in byproducts and development investigations.

ACTION

The group recommended:

1. The continuation and expansion of Public Law 159.
2. The creation of a stronger liaison between Government and the general public and the establishment of a liaison between Government and industry. (With these efforts toward better liaison, we will have an understanding of the meaning of our living together in a cooperative effort.)
3. Governmental cooperation with local organizations in the development of programs and effective measures which will further effective and fair air-pollution control.
4. Machinery to be set up to promote periodic national meetings for the comparison and evaluation of air-pollution-control progress.

Dr. Christopher E. Barthel, Jr., *Chairman.*
Arthur Crago, *Vice Chairman.*
Dr. C. Stafford Brandt, *PHS Resource.*

Discussion Group "E"—Control Methods and Procedures for Air Pollution

SUMMARY

During the past decade, substantial progress has been made in basic knowledge and in the technology and practice of air-pollution control. Industry and Government both have contributed to this progress. Industry is spending millions of dollars a year in research and hundreds of millions a year in control of air pollution. Government and nonprofit agencies are also spending large sums of money for similar purposes. These expenditures have resulted in substantial improvement.

Scientific, engineering, and trade associations have held numerous conferences on air pollution in recent years. Their publications have presented useful scientific and engineering developments. These publications have promoted wide application of the new knowledge, particularly in larger installations, but more effective use of the present knowledge can be made.

The means are presently available for adequate removal of many pollutants within cost limits which are economically feasible. Such means are not available for certain other pollutants, but in many of those cases removal is desirable but not essential. The economic justification depends on the conditions which exist in each instance. For many of those pollutants for which the need of control has been most urgent and widespread, economical methods for correction have been developed. In certain industrial applications the control cost results in a direct charge to the local industry which, in turn, passes on this cost as an increase in consumer cost to the local community benefiting from the application of control; in others, it results in a consumer cost which is borne nationally. In the case of municipal and domestic sources, the direct cost of control is borne by the community.

It is recognized that a public awareness should be directed to the value of industry standards and principles applicable specifically to new installations having a significant air-pollution potential for the purpose of minimizing the development of new air-pollution problems in the future.

RECOMMENDATIONS

1. The committee recommends that it is a joint responsibility of Government and industry to sponsor and conduct research on air-pollution control. It is recognized that industry welcomes Government support of research as a means of identifying, defining, and developing approaches to solutions. The responsibility for the solution of specific problems associated with a specific industry or plant lies with that industry.

2. Further research and development should be implemented to expedite controlling emissions from high-temperature combustion and metallurgical operations.

3. Further studies must be undertaken to develop economic means for the removal of low concentrations of gaseous pollutants such as oxides of sulfur and nitrogen from combustion gases for application in areas where these may be a problem.

4. We urge that the education and training of engineers in the field of air-pollution control should be continued and, if possible, expanded.

5. Recognition should be accorded to the importance of developing economical survey techniques that can quantitatively define the relative importance of the application of control equipment in a community.

6. Properly designed and engineered control equipment should be incorporated in the initial plant specifications. Codes for guidance in this practice should be developed by voluntary industry groups and engineering societies. Support for this endeavor should be encouraged.

7. In regard to automobile exhaust emissions, the following recommendations are made:

   (*a*) Work on the development of analytical techniques and instrumentation and studies of exhaust-gas composition should be continued by both industrial and governmental agencies.

   (*b*) Those industries presently engaged in developing exhaust-system control devices should continue their work at a vigorous rate.

   (*c*) The automobile industry should continue its study of the maintenance aspects of the automobile exhaust air-pollution problem.

8. Research agencies should continue their program on the health aspects of all air pollutants in order to expedite the development and application of control methods.

9. The study of atmospheric reactions should be continued so that as control methods become available those urban areas affected with an air-pollution problem can determine whether or not the application of such control methods will be effective in their particular problem.

Dr. LESLIE SILVERMAN, *Chairman.*
WESLEY C. L. HEMEON, *Vice Chairman.*
ANDREW H. ROSE, Jr., *PHS Resource.*

Discussion Group "F"—Administrative Aspects of Air Pollution

I. *Question.* What are the respective responsibilities of the individual, business, and industrial activities, and public agencies in the prevention and control of air pollution?

Answer. The control of air pollution requires the cooperation of the whole community. While an industrial source may contribute more than an individual, it should be recognized that the total contribution to the air-pollution load by individuals may equal or exceed that of industry. The individual has responsibility to prevent or reduce air pollution resulting from open fires, trash incineration, home heating plants, and improper functioning of his automobile within the technological limits which exist at the time.

As an integral and vital component of the community, business and industry have a responsibility in the prevention and control of air pollution as a good neighbor and for the general welfare of the community. In this regard, it is incumbent upon them to recognize that air is a limited natural resource. The use of the air is common to all, and neither public use nor custom grant special consideration to any components of the community.

Local public agencies have responsibility for dealing with the air-pollution problem through several approaches. First, the community must take the initiative in providing services for the collection and disposal of refuse in a manner which will not pollute the air. Second, the public agencies should conduct their operations in an exemplary manner to avoid pollution of the air. Finally, that local or regional public agency which is capable of dealing with the air-pollution problems in the area should be given the responsibility for the conduct of a control program. This intends that recognition be given to those factors common to such an area because of topography, meteorology, sources of pollutants, and effects.

The appropriate State agencies should assume responsibility for leadership, technical assistance, and guidance to the local control agencies. In this manner, the State can function effectively by assisting local agencies in appraising their air-pollution problems and providing necessary technical assistance. The State agency should also maintain a continuing program of study and appraisal of air-pollution levels throughout the State. The State should encourage local control legislation and local control operation, where feasible, but the State should assume the responsibility for control in all those areas where the organization of local or regional programs is not feasible, or where a local control program is needed and has not been established.

The most effective manner in which to assess relative responsibilities in a community would be by means of preliminary study and appraisal of the air-pollution problems. This should be followed by a determination of responsibilities in a cooperative manner, recognizing the equities involved.

The role and responsibility of the Federal Government is clearly expressed in Public Law 159 of the 84th Congress. This act provides for the conduct by the Public Health Service of a program of research, technical assistance, and training. This law was enacted in 1955 and provided for an initial period of 5 years of Federal activity in this field with the intent of reappraising the problems and needs at the end of that time. Although much-needed research results have been achieved, it is not possible to accomplish the objectives of the act within the 5-year period. For example, the effects of air pollution on health and the control of automotive exhaust gases are but two of the many vital problems on which further work needs to be done. In the public interest there is continuing need for research which can best be conducted by the Federal Government. The nationwide importance of air-pollution problems indicates the real need for amending Public Law 159 to extend the authorization for the program.

The Congress in enacting Public Law 159 also included a provision limiting the annual appropriation to a maximum of $5 million. Air-pollution research includes many complex aspects involving study over an extended period of time, particularly those concerned with the chronic health effects. This fact, together with the possibility of an engineering or medical research breakthrough which might make desirable an expansion of activities for further development and exploitation, suggests that no appropriation limitation should be included in the extension of the act. The annual budget review and appropriation procedure provide adequate financial control. The air-pollution problems of our country are vast in scope and, if unchecked, will without doubt increase in severity due to the rapid increases in industrialization and urbanization which are taking place; therefore, we feel it is undesirable that a ceiling be placed on the funds authorized by the Congress for work by the Federal Government in this field.

II. Q. In general, in the conduct of air-pollution-control programs (*a*) should air-pollution control be organized on a local basis? Regional? State? Other?

A. Public Law 159 specifically declares it to be the policy of Congress to preserve and protect the primary responsibilities and rights of the States and local governments in controlling air pollution. This policy declaration is clearly in harmony with the Federal Constitution under which the police powers, with certain exceptions, are reserved to the respective States. Thus, the control of air pollution, as an exercise of the police power, is a responsibility primarily of the States and, to the extent delegated by them, of their political subdivisions.

In many cases, air pollution can be dealt with by a single local political subdivision. Air pollution, however, frequently does not respect political jurisdictions and consequently many communities are unable to deal effectively with this problem on an individual basis. Experience thus far clearly indicates the desirability of meeting the air-pollution problem on a problem-area basis. This would involve, as the case may be, purely local or regional efforts, the latter by interlocal or interstate cooperation. As one practical approach, the Council of State Governments has suggested State enactment authorizing cooperative activities between local subdivisions on a joint basis. The act would permit the exercise of power already possessed by a political subdivision in conjunction with one or more communities for a common end. It should be noted that the suggested act is drafted for use between or among communities, whether or not they are located within a single State.

There are some situations which are primarily regional and dependent upon a number of common factors, such as weather, topography, population concentration, and industrial development, among others. A number of State legislatures have recognized this need and have enacted appropriate enabling legislation. In the control of air pollution, it is clear that the functions of the States lie in two general categories: (1) those concerned with the legal delegation of appropriate powers to their political subdivisions or groupings of them, and (2) those concerned with the direct activities of the State government itself. For the first, State initiative and action is a necessary antecedent to effective local or regional activities. In addition, there is need to encourage cooperation and coordination between States in dealing with interstate air-pollution problems. The Federal Government in the exercise of its jurisdiction over commerce on navigable waters should delegate authority for control of air pollution to the States.

(*b*) Q. What relative emphasis should be placed on education, voluntary action, regulation, legal enforcement?

A. The active cooperation of the various components of the community is most desirable and essential for a successful air-pollution program. There is also the necessity of achieving a proper balance among the elements of a community air-pollution program, appropriately tailored, which would include, among others, education, cooperation, regulations, and legal enforcement. Education of all concerned plays an important role in securing understanding and cooperation. It provides the means of describing the problem, needs of the community, and what can be done.

The rules and regulations establish the objectives. The promulgation of such rules and regulations performs the significant function of guidance and provides a uniform approach, where applicable, to the air-polution problem. Obviously, for the recalcitrant few, there is need to resort to legal remedies. The legislation must be reasonable and just, based upon a sound technical foundation.

(*c*) Q. What is the role of zoning in air-pollution control?

A. At the present time, satisfactory acceptable variations in standards of air-pollution control relating to zoning and planning have not been evolved. It is recommended that planning and zoning experts, working together with air-pollution officials, devote further study and research to this problem.

(*d*) Q. How should air-pollution control be paid for?

A. This question involves two aspects: first, the cost of operating the control agency; and second, the cost of providing and operating processes or equipment for actually preventing or controlling air pollution.

All segments of the community are concerned with the control of air pollution, and many of them are affected by the financial equities involved. The official control actions, undertaken in the overall public interest, should be supported, therefore, by public funds. This may be tempered by an appropriate system of equitable fees covering the cost of special services rendered by the official agency to individuals or business and industrial organizations.

On the other hand, every individual or organization must be expected to defray the cost of necessary steps in preventing or controlling air pollution which would otherwise result from activities carried on or controlled by him.

Dr. Louis C. McCabe, *Chairman.*
Harold W. Kennedy, *Vice Chairman.*
Samuel M. Rogers, *PHS Resource.*

What of the Future?

Arthur S. Flemming

Secretary

U.S. Department of Health, Education, and Welfare

I am very happy to have this opportunity to participate in what I certainly regard as a very significant conference. My only regret is that the Cabinet meeting this morning made it impossible for me to spend the entire morning with you. I had looked forward to the opportunity of listening to the various reports that have been presented to you as a result of your discussions together. And I had also looked forward to listening to your reactions to those recommendations.

It seems to me the fact that more than 900 people have taken time from their busy schedules to respond to Dr. Burney's invitation to attend this conference is clear evidence of the importance of air pollution as a national problem.

Speaking on behalf of all of us in the Department of Health, Education, and Welfare, I want to thank you for coming here, participating in the conference, and giving us the benefit of your counsel.

It is my understanding that the 3 days of meetings are to be summarized in this afternoon's session. Again, I wish that I might have had the opportunity of listening to that summary.

But, as far as your reports are concerned, I want to make this statement:

I can assure you that all of the recommendations that you have made which bear on the duties and responsibilities of the Department of Health, Education, and Welfare, and specifically the Public Health Service, will be considered very carefully.

I can assure you that you will know what has happened to your recommendations. If we agree, we, of course, will be very happy to indicate our concurrence. At times, or on connection with some of the recommendations, it may be necessary for us to indicate partial concurrence. If we do, we will give you our reason for feeling that we cannot travel the whole distance with you.

Also, if we feel that it is not possible for us to agree with one or more of your recommendations, we will let you know why we did not find it possible to agree.

I do not think there is anything more frustrating than for a group of citizens to come together in order to deal with a major problem such as this one, to make recommendations to the Government, and then not know what happens to those recommendations. I can assure you that you will not have that kind of an experience as far as this conference is concerned.

Since coming into the auditorium, I have had the opportunity of scanning the report dealing with the administrative aspects of air pollution. This is a report in which I am certainly very much interested. It is a report which I personally will be very happy to study carefully. In going through the report very rapidly, however, I noticed that it is a well-balanced report, in that it indicates that there are many areas of our society that must participate in the handling of this problem. It seems to me that the report very appropriately points up the responsibility of the individual citizen as well as the responsibility of business and industry, and also the responsibility of our Federal, State, and local governments.

Naturally, I am particularly interested in what this report has to say about the role and responsibility of the Federal Government. I note that those who prepared this report and submitted it to you feel that the role and responsibility of the Federal Government is clearly expressed in Public Law 159 of the 84th Congress. This report underlines the fact that this act provides for the conduct by the Public Health Service of a program of research, technical assistance, and training.

The report also points up the fact that when the law was enacted in 1955, it provided for an initial period of 5 years of Federal activity in this field, with the intent of reappraising the problems and needs at the end of that time.

I note the recommendation of those who drafted this report to the effect that in their judgment this law should be extended. I concur wholeheartedly in that judgment, and I will be happy to do everything I can to bring about the extension of the law.

I think that is makes good sense for us to attempt to obtain this extension during the first session of the forthcoming Congress. I recognize that the law does not expire until June 30, 1960, but I feel that in the interest of keeping the program moving forward, it would be wise to obtain the extension during the first session.

So right now I am perfectly willing to react to this particular recommendation, and to say to you that I concur in it and will be very glad to do everything possible to see to it that the recommendation is implemented.

I notice that this report has something to say about the financial provisions of the law.

As you can appreciate, I am not in any position to comment on that at the present moment because it involves an item in the President's budget, and we are not supposed to talk about the budget until it has been presented by the President to the Congress.

I do note that you suggest that no appropriation limit be included in the extension of the act. And I note the suggestion that the annual budget review and appropriation procedure provide adequate financial control.

As one who is right now in the midst of the annual budget review, I can testify to the fact that it really does provide financial control! Whether it is adequate or not, of course, is a matter that is subject to debate. But that particular sentence of the report dealing with the fiscal aspects of the matter is certainly not an overstatement, but possibly even an understatement.

As I have indicated already, I have been interested in noting how this report places responsibility on various segments of our society for dealing with this problem. There is no question but that society is going to have to make a real investment if the air-pollution problem is to be handled in an adequate manner.

As I have had the opportunity of working with my associates on problems in this and other areas, I have developed a growing conviction that if, as a society, we are going to deal effectively with such problems, it is going to be necessary for us to reach agreement on what I like to think of as national goals.

Let me give you an illustration of what I have in mind.

Just before I took office, a very distinguished group of consultants filed with my predecessor, Secretary Folsom, a report dealing with opportunities in the fields of medical research and training.

The authors of that report suggested that by 1970, 12 years from now, the United States, as a Nation, should be investing approximately a billion dollars a year in medical research and training.

They also suggested that by 1970 the Federal Government should be investing a half-billion dollars in medical research and training.

Then they went further and suggested that the Department of Health, Education, and Welfare should be investing approximately $350 million of that $500 million.

Now, I am not at this time commenting on the recommendations relative to either the time or the amount of money that we should be investing in this very important area of medical research. I cite this example simply to illustrate a sound approach, not only to our activities in the field of medical research, but to our activities in many other areas for which we have responsibility.

You can see what these consultants did: they suggested a national goal. And then they suggested what, in their judgment, constitutes a fair share for the Federal Government, and a fair share for philanthropy and industry. Because it was their suggestion that while the Federal Government should be investing a half-billion dollars a year in medical research, philanthropy and industry, by 1970, should also be investing a half-billion dollars a year in medical research.

As we move into this area of air pollution, I hope that, by working together, it will be possible for us to agree on a national goal, to agree on the amount of money that should be invested in this area by both public and private sources.

Now, when I say this, I recognize that possibly in order to arrive at a satisfactory result, it may be necessary for us to break down this area of air pollution into certain subareas.

Let me give you one illustration: there is no doubt at all but that if we are to move forward in dealing with this particular problem, it will be necessary for us as a society to make a substantial investment in research activity. My hope would be that, working together, we could arrive at agreement as to how much should be invested each year in research. And then, I would hope that we could reach agreement as to what constitutes a fair share of this total amount for the Federal Government, for State governments, for local communities, and for, let's say, business and industry.

In other words, having agreed on the total amount, how much should we invest in the way of public dollars, and how much should we invest in the way of private dollars?

Now, you will note that I have stressed the desirability of reaching agreement. I know, as you do also, that it is absolutely impossible for the Federal Government to impose a national goal in this or any other area. The Federal Government can take the initiative, just as the initiative has been taken by the Federal Government in calling this conference. It can also take the initiative in bringing together those who should be brought together in an effort to reach an agreement as to what investment should be made by our Nation as a whole, each year, in connection with research activity directly related to the field of air pollution.

Then, having reached agreement on the overall figure, I believe that it should be possible to reach agreement as to what constitutes a fair share for the Federal Government, for State and local governments, and for private groups.

I recognize that it isn't easy to go through a process of that kind, and that certainly it isn't easy to reach agreement either on the overall goal or on what constitutes a fair share for various governmental units and for various private groups. But I am convinced that if we are to make substantial and intelligent progress in the direction of dealing with problems such as air pollution, it is going to be absolutely necessary for us to go through such a process.

It is one thing to talk in generalized terms of the need for research in this area. It is another thing to translate those generalized statements into dollar goals, and then, to say to the Federal Government, to State and local governments, and to private groups, "Here's what you need to do if we are to reach our national goal." This gives all of us a handle to take hold of, something to use as we talk in terms of the dollars that should be invested in such a program.

I recognize, as I am sure you do, that we do not get very far by simply underlining the need for something. The only way we can make progress is to translate our convictions into dollars; because that is the way we can indicate the kind of contribution society must make in order to deal with certain problem or opportunity areas.

My hope is that, as a followup to this conference, we will get together to see if we can reach agreement on the total amount of money this Nation should be spending each year for research in the field of air pollution, and to see if we can reach agreement on what constitutes a fair share for the Federal Government, a fair share for State governments, a fair share for local governments, and a fair share for private groups. We will be more than happy to work with you in an effort to reach such agreements.

I have stressed the research aspects of the total problem, but I think that we can take other aspects of the total problem and apply the same approach.

I recognize that our immediate and very pressing need is for additional research in this area. That is why I suggest the possibility of taking this approach in the research area. If we do, our attempts to obtain funds to carry forward research will rest on a much more solid foundation than would be the case if we merely pulled figures out of the air, figures that we think represent a desirable investment.

I may pull one figure out of the air, someone else may pull another figure, and because we haven't reached agreement, because we are confused as far as our ultimate goal is concerned, those who are not very sympathetic with what we are attempting to do will take advantage of our confusion.

On behalf of all of my associates in the Department, I congratulate you on your willingness to come here and devote these 3 days to this all-important opportunity.

And may I congratulate you on the job that you have done. You have rendered an outstanding service to all of the citizens of our Nation, and all of the citizens of our Nation are indebted to you for what you have done. You have presented to us some challenging opportunities. I can assure you that we will do everything that we possibly can to measure up to the opportunities that exist for service in this all-important area.

Comments by the Surgeon General

Dr. Leroy E. Burney
Public Health Service

I got up at 5:30 this morning in order to talk about air pollution on a television program. I mention this because the wide interest of the press and TV and radio is an indication of the interest the public has in this particular issue. I think we owe a vote of thanks to these media for presenting, from what I have seen, a factual and objective reporting of this conference.

In problems involving emotions and tensions, one cannot expect to secure universal agreement on what is being done, or what ought to be done, or how it should be done. And I am not sure that would be a healthy attitude, anyway. With a little disagreement among each other, as long as there is more light than noise, one can expect the ultimate goals the Secretary has mentioned to be enlightened and objective goals.

We should be thankful that we live in a country in which we can come together, as individuals and as groups, representing diverse interests and with different ideas about how to resolve a certain issue, and that we can stand up here and say what we believe and have it reported in a free press and a free radio and a free TV.

So I am not at all concerned that there have been some differences of opinion, and that there will continue to be.

I think it would have been worth while if this conference had done nothing more—and it certainly has done a great deal more—than to provide an opportunity for each of us, regardless of what our professional category may be or what particular group or organization we represent, to learn this one thing: that there are many groups that have contributions to make to this problem and that none of us has an isolated or circumscribed role in resolving this particular issue, whether it is in the research field or in the application field.

As Secretary Flemming has emphasized, we do need more research in this area, but we do not need to wait until we have more research to make more application of the present available knowledge.

It is very gratifying to me to learn of the very fine efforts being made continuously by the various air-pollution-control bodies throughout the country, the excellent work they are doing and have done under considerable handicaps.

Afternoon Session—Thursday, November 20

Chairman

Dr. John D. Porterfield
Deputy Surgeon General, Public Health Service
U.S. Department of Health, Education, and Welfare

OPEN FORUM DISCUSSION

Mr. Linsky. I have heard little mention of the agricultural problems, both agriculture as a victim of air pollution and agricultural operations as sources of air pollution. Can you give us some information about the present program with respect to this kind of work?

Dr. Chambers. There has been, in our section, only rather limited consideration of agricultural activities as a source of pollution, although it is clearly recognized that in local areas agricultural operations of various sorts do contribute to local nuisances and possibly to deleterious effects on the community.

In some areas, the burning of orange groves as they are cleared for other operations has caused smoke nuisances.

We are aware of the problems that have been raised by the spreading of pesticides, defoliants, and the like, with the potential for damage to water supply and to persons and animals and crops directly.

But beyond recognition of the fact that these problems do arise, they have not been considered by our group very extensively. I believe the major contribution would come from the group that has been concerned with the economic aspects of this problem.

Dr. Brandt. In our section, Mr. Charles Butler, of the American Farm Bureau, presented a review of the problems facing agriculture and agriculture's contribution to the air-pollution problem. One problem arises from spray programs, which in local areas are being controlled through various health agencies and State departments of agriculture. Another problem arises in communities like Mr. Linsky's from the burning of agricultural wastes. They involve engineering problems that probably should be considered by the group on control measures and procedures.

Dr. Silverman. We had several discussions relating to the chemical industry, which, of course, produces agricultural chemicals as well as many others. We concluded that we need survey techniques to define quantitatively the importance of the application of control equipment in a community, and this could be an agricultural community as well as any other.

We also made the point that properly designed and engineered control equipment should be incorporated in initial plant specifications. This would pertain to a cotton gin, an alfalfa-drying plant, and any number of comparable operations which we know have created nuisances in various communities and where the economic aspect is marginal because farmers' cooperatives and so on are not capable of providing funds, in many instances, for all the purposes involved.

We did not put a great deal of emphasis on this, but we certainly do not wish to ignore such problems. They can be controlled if the economics can be made favorable, and in some instances it is necessary to control them.

Dr. Merrill. We have a problem in California now and then that is tied in with agricultural operations. Our State health department first got involved in air pollution as a result of the dust created about turkey farms. A rather severe problem is the blowing away of the topsoil in the asparagus growing areas of the lowlands, San Joaquin, and Sacramento Valley, where the city of Stockton has experienced rather severe inundations of the dust from this area.

Mr. Stern. Studies have been going on for several years on the control of effluent from cotton ginning, this work being done at the request of the health departments of several Southern States, and with their cooperation, by the U.S. Department of Agriculture experiment stations in Mississippi and South Carolina. Similarly, in cooperation with the State health departments of Kansas and Nebraska and the Alfalfa Dehydrators' Association Cooperative, investigations of the problem of alfalfa dehydration have been made and the results will be published shortly.

Dr. Maurice Kamp. Since it will be some time in the indefinite future before you can prove some of the health hazards of air pollution, and since it will probably take longer to approve the emotional and mental health hazards, would you advocate, instead of the maximal allowable concentrations, some standard which is related to comfort, such as the maximal allowable comfort concentration?

Dr. Merrill. From the public health standpoint, anything which makes a person uncomfortable, decreases his efficiency for work, or interferes with his general well-being in the broad sense represents a public health problem. Air pollution does interfere with the health and well-being of the individual. And, as public health workers, we would like to see this comfort level established as a level to work toward. We would like to see ultimately a level at which no one would be conscious of the atmosphere, even from the nuisance standpoint. We realize that this is an ideal that is, possibly, not achievable at the present time.

Dr. Silverman. Now we are getting into a matter of economics; how much money it would cost to obtain this comfort situation. Some of our problems arise from a multiplicity of sources, and this makes it difficult from a control standpoint.

Dr. McCabe. On the administrative side, we would want a sound foundation established in fact before we would attempt to put in such a system as that. It may be unfortunate that it takes so long to get the necessary facts, but in this case, where we are establishing maximum allowable concentration, I would rather see us take the time.

Mr. Stern. The analogy is frequently drawn between the maximum allowable concentrations of industrial hygiene and the possible eventual achievement of maximum allowable concentrations in air pollution. I think it should be noted that some of the maximum allowable concentrations used and accepted today in industrial hygiene practice are, in fact, sanitary standards.

Mr. Gruber. Was there in the committee discussion a more specific reference to what type of research is needed on control equipment and control measures than we have had today?

Dr. Silverman. We agreed that there were three principal areas in which further research on equipment was needed urgently, some of which is under way, but might be expanded. One of these is, as you have heard many times, the automobile exhaust problem. Another is the problem of cleaning high-temperature gases. Still another one is the problem of sulfur dioxide and sulfer trioxide in certain areas. All of these investigations, we feel, should be pointed toward more economical solutions.

We also indicated that there is already a large amount of scattered information; what we need is more correlation and a means of predicting, from the nature of the process, how a piece of equipment would perform.

We feel that the so-called particle identification, or parameter development, is very essential. If we could know something about the process and particle size, shape, or specific gravity, we might be able to predict what type of equipment would be of value. If we could measure resistivity of dust, it would give some indication of the performance of a precipitator. It was brought out in our discussion that sometimes precipitators have been unable to cope with the problem because there was not enough knowledge of the behavior of the dust itself.

Mr. Rose. We should add that new metallurgical processes are rapidly expanding and that research on the control of effluents in these processes will be increasingly important.

Mr. Gruber. What about predicting the effectiveness of the cleaning equipment for a different application? That is important to us as control officials.

Dr. Silverman. We certainly feel that the parameter should give some indication of the effectiveness of equipment and show whether a scrubber or a precipitator or some type of dry filter would be the correct application. The general range of performance is indicated but occasionally you run into situations where the dust turns out to be very sticky or to have properties that weren't anticipated, and this causes plugging and problems with filters that can't be shaken or cleaned. So there still remains a certain "gray" area which calls for experience and testing, even though you might do a pretty good job with the particle and process parameters.

Ellis E. Smauder. In one of the very fine films shown here, there was very definite mention of the banning of incinerators. If there were a few words left out, it may be well to correct that part of the film to indicate that they intended to ban the single-chamber incinerator or the backyard incinerator. I don't believe that this country is ready yet to ban the burning of refuse in properly designed incinerator equipment. Such equipment is available.

The other film serves a very good purpose, but there was no reference to the good that could be done by the proper incineration of refuse. At another point in that film, I saw my incinerator industry going to the bulldozers, along with the trash and papers.

This group should know that there are new designs available in all types of incinerators, from the residential to the largest permissible incinerators, types that can be built in close-in areas in the larger cities and be operated without problems.

Mr. **Rose.** This problem was one we discussed in the control group. Basically, it resolved itself into a matter of economics. There are certain installations where your incinerator is your cheaper process of disposal. There are others where land fills are cheaper.

Dr. **Silverman.** Mr. Bowerman presented at our session figures of $1 per ton for land fill or, with excessive haulage, $2.80, as against $3.80 for combustion. He pointed out that they are eventually going to have a problem finding land-fill areas. But for the moment the economics is in favor of land fills.

Mr. **Smauder.** The only comparison between land fill and incineration that I have heard has been between today's fine type of land fill, properly operated, and our forefathers' municipal incinerators, which were nothing like the latest equipment. We no longer can afford to operate small plants for large cities such as Washington or Chicago or Los Angeles.

William A. Xanten. With respect to municipal incinerators, there are great bills for destruction of rubbish in this country, greatly increased in the last decade. This has placed a great many municipalities in the position of building a boy's incinerator to do a man's job. The plants that have been built have turned out to be atrocious because they have been overloaded. As indicated by Mr. Smauder, a 1,000-ton incinerator usually can do a fine job on a 500-ton load. If we are to make any improvements in incinerating refuse, we should reduce the gradings of the incinerators so that they are realistic with respect to their real capacity, and not attempt to do a job twice as great as the plant was designed to do.

I would also like to ask if there isn't some justification for research in developing more simplified methods of measuring stack discharges, particularly with respect to particle matter, rather than coloration.

Dr. **Silverman.** We have said on other occasions that the development of stack sampling equipment that was simple and reliable is urgently needed. This is an item which several agencies are working on, including the Taft Center, and several types of equipment have been developed. We have done some work at our lab along these lines, which would be applicable to high-temperature stacks, such as incinerators and metallurgical stacks.

The equipment is available. But a certain amount of technique has to be acquired, and there are certain types of equipment that work for high-temperature gases where the moisture is no problem, and under other circumstances.

We do need some further work, and I think there is one industry group that has indicated the desirability of developing a technique that would be accepted by all the other industry groups, so that we would also have something we feel is very important, a way of comparing results.

Dr. **Chambers.** This problem was also considered by the group discussing sources of pollution. This group recommended exploration and development of methods for analysis of source sampling applicable to this problem and others.

The emphasis among the speakers was in three directions. One was toward a higher degree of reproducibility and dependability in the instruments or procedures.

Another was a higher degree of specificity in certain cases. This may not be applicable in the case of the incinerator, although it probably is. And, finally, the third was in the direction of decreased cost and ease of application in terms of manpower.

We feel that, not only in the area of dust analysis and emission from incineration, but also in connection with most other sources, there is room for rather extensive research and development along instrumental and methodological lines.

Dr. Rossano. It is also recognized that, in this area of assessing the emission from incinerators, what is lacking is a pool of highly trained, specialized people who could carry on this work. One of our recommendations was to increase the pool of specialized personnel.

One other point is that perhaps there should be more information available on discharges from incineration. We hope that in the future we can get information of this type, analyze it, and disseminate it to those who are interested in this particular phase of air pollution.

Dr. B. S. Levine. During the discussion in the health effects group on the impact which certain air pollutants have on people's health, as manifested by purely clinical, visible symptoms—or perhaps syndromes and, to some extent, emotional upsets—I did not hear any mention of the effect of air pollutants on what the Pavlovian neurophysiologist would call higher nervous activity. This controls the unconditioned and conditioned reflexes, which by many are considered as the primary armamentarium through which the organism adapts itself and can protect itself against certain environmental conditions. Has that effect been considered?

Dr. Merrill. We did discuss some of the intricacies of the physiological effects on the air sacs of the lung, and the possible reflex influence this might have on the cardiovascular system. But the specific type of reflex activities you mention did not come into the discussion yesterday.

Dr. Heimann. Dr. Levine is talking about the material developed in the U.S.S.R., and refers to the Pavlovian theories and modification of those theories by current experiments in the U.S.S.R. We in this country have not done any work in that direction, nor did we discuss this.

Dr. Levine. Most of the methods being used now in determining limits of allowable concentration are limited to experiments carried out on animals and questionnaires to persons. The questionnaires, being strictly subjective, are void as primary sources. The experiments on animals have been transposed to human beings, and do not have a direct bearing.

But if you can arrange that your latent period of conditioned or unconditioned response can be automatically recorded, you may have a means of detecting fine effects of certain pollutants in an automatic, purely objective manner. You would be able to detect the bad ones, and check them for limits of allowable concentrations of certain pollutants.

Dr. Dorothy Muncy. As a practicing consultant on city planning, I would like to propose to Group D: Economic and Social Effects, and Group F: Administrative Problems in Air Pollution, that they add to their recommendations the need for active cooperation between air-pollution officers and city planners to prevent air pollution in the still open areas of our expanding metropolitan regions.

I emphasize "active cooperation," because the recommendations from group F were that there be further research in the field. We all believe in research, just as we believe in God, country, and motherhood, but surely our present imperfect knowledge is something we must employ now if we are to prevent pollution problems as our industries expand.

McGraw-Hill recently came out with a survey indicating that upward of 50 percent of our industrial capacity in this country is considered not adequate for the competitive situation in industry today, which means we are going to have a building program in industry far greater in the next 20 years than we have seen ever before.

Surely, the air-pollution officers can give city planners advice on the locations within regions in which we should encourage industries to locate their plants. And they can begin to give us advice, imperfect as it may be, on the degree of industrial concentrations at any given point. And possibly, even, they can begin to give us advice on the types of industries which should be encouraged to expand in given metropolitan regions.

Dr. Barthel. The initial paper of our session was presented by a planner, and he feels quite strongly, along the lines of your comments, that the city, or the urban area, must know something about future plans, and also that it is unfair to permit industry to come into an area without knowing those plans, also.

The record of our session should cover this point fully. We list under "Action," not "Research":

> Encouragement of governmental cooperation with local air-pollution organizations in an effort to develop programs and effective control measures which will point out effective and reasonable air-pollution controls.

Dr. McCabe. I agree with Dr. Muney. Unfortunately, when we were working on this, our zoning expert was not with us. Certainly, in new areas there is opportunity for the application of zoning to the full extent. It is not so simple in built-up areas of cities; that also calls for collaboration of the air-pollution expert and the zoning specialist.

Dr. Merrill. Planning is certainly important to us public health officials. Also, there has come to the attention of some of us, at least, the role of planning for transportation within our metropolitan areas. The whole question of rapid transit and mass transportation comes into the same general category of possible approaches to diminution of the sources of atmospheric pollution, which we would hope that the people who are planning our metropolitan areas would take into consideration.

Dr. Rossano. Dr. Muney brings up a very important point. It embraces the philosophy of prevention, which is so familiar to us in the public health field. Some efforts were initiated about 2 years ago by the air-pollution program at the Sanitary Engineering Center in cooperation with the city of Tulsa, Okla., to make an air resources survey. The study is still in progress. It involves a study of the meteorology, topography, and potential of the area, so that the community can plan the orderly development of its industry, and so forth, without introducing any further air-pollution problem.

Dr. McCabe. We are probably inclined not to give as serious consideration to this matter of planning and zoning as we should because we think perhaps it isn't too practical. A good example of how practical it is, though, is that in the rebuilding of some of the British cities since the war some of the bombed-out areas have been planned rather carefully, and areas of the city are set aside for industry. These and other areas were chosen with regard to meteorology, topography, and so on. The British have built tree belts. They actually have smokeless zones. They may lay out one zone for industry, then a tree belt, a residential area, and so on.

In our own immediate area of the Capital, there is being suggested an application of this discipline to the nearby Montgomery County area, where Dr. Muncy has laid out some industrial areas. And we would hope to build those into what we call industrial parks. Fortunately, they aren't built up heavily yet. They have dairy farms and that type of thing. We hope to apply zoning and planning to bring into this particular area only light industry, to protect it from heavy industry that might pollute the atmosphere.

Dr. Porterfield. The State of Texas has recently enacted legislation which calls for the State department of health to review city plans for new large developments prior to their approval, from the point of view of health problems. This, too, is action rather than research.

Francis Silver. Mr. Griswold stated in one of our group discussions that, even if they had an effective gadget to put on automobiles, it might take 5 to 10 years to get it generally installed. In view of this longtime delay, have all other ways of limiting the volume of air contaminants from auto exhausts been explored?

Dr. Chambers. I assume that Mr. Griswold was commenting to the effect that, even if some technique that required a mechanical installation were available right now, the mere mechanical problem of producing the gadget, distributing it, and having the installation made on a few million vehicles would require some time, years, perhaps.

The second part of your question, as to whether or not all other possible approaches have been explored completely, I think has to be answered no. I would add, however, that, in my estimation, all possible approaches are being explored.

One of the difficulties with this problem, so far as development of controls is concerned, lies in the fact that there is still missing a tremendous amount of basic information about the nature of the problem, the chemistry of the automobile engine and of its effluents, and about the relationship between the gasoline put into the tank, the form of an engine, and the form of the exhaust system. All of these things are interrelated in such a way that the combination of factors affects the design of any control procedure that has been suggested so far.

Not quite as pessimistic as your question indicates Mr. Griswold to be, I think there are principles that at the moment deserve the exploration they are getting, and perhaps considerably more exploration, that may not require so long a time as he indicated. I will say that nothing is immediately in sight that would indicate that we can have a device on a substantial number of the vehicles in Los Angeles, specifically, within 2, 3, or 4 years.

Mr. Silver. Have such things as gasoline rationing to users or stations been considered? More emphasis on car pools or electrified mass transportation systems? Or restricting the sale of new cars with excessive horsepower? Or insistence on good maintenance?

Dr. Chambers. All these things have been explored. None of them has been exploited extensively, with one possible exception. About 18 months ago an attempt was made, in cooperation with major industries in the Los Angeles area, to promote the use of car pools to increase the number of riders per vehicle, because in our area we have about 1.2 persons per car on the freeways. Obviously, if we could double up, that would help to cut down the number of cars. On a voluntary basis, and even with incentives to the formation of car pools provided by the employers, frankly, this effort was a failure. With respect to other possibilities, such as the restriction of the use of automobiles, or gasoline rationing, they might be possible during an extreme emergency or a wartime period, but so far these things have not been suggested. There is a danger—frankly, this is the one thing that worries me most—that if some control device that is purchasable and installable is not available within a reasonable period of time there will be such a demand for action that it may be necessary to regard it as an emergency, and that really drastic actions of that sort, which we now hope to avoid, may be taken. I hope not.

There are obviously a great many possibilities of this sort: restriction of driving, restriction of gasoline consumption, the enforcement of pooling of riders, and in the long range the construction of rapid transit systems. Of course, this last is being explored, but it is not an easy solution to the problem after a city of 6 million has developed almost completely without a rapid transit plan.

Dr. Porterfield. This matter of the timelag between the development of the knowledge and its application to appreciable parts of the population is one which arouses considerable emotional response in your chairman, also. I might remind you, on the one hand, that it took approximately 100 years from the development of smallpox vaccine to any kind of application to the population at all. In more recent years, on the other hand, it has taken us only a few years after its discovery to achieve a fair percentage of coverage by Salk vaccine.

Dr. Lyman Ripperton. All over the country today, local health departments are becoming involved in air-pollution control, groups that have had very little experience in this area before. I would like to ask Dr. McCabe and Mr. Rogers to comment on the adequacy of the public-nuisance laws for use in air-pollution control, and, if they don't think these are adequate, what guiding principles the local authorities should use in setting up legislation for air-pollution control.

Dr. McCabe. My feeling is that, as a general thing, the common-law nuisance law is not adequate because it is not specific: it is difficult to demonstrate a common-law nuisance.

For the guidance of both those producing air pollution and those on the receiving end, it is well to have the ground rules spelled out, as it is well to have speed limits set in certain parts of the city or on the highways. It is a guide and a protection against abuse in both directions, to both the recipient and the source of the air pollution. If your rules and regulations are adequate, it means that they are complied with, they are enforced, and there will be improvement. It also means that once the rules are made, if they are adequate, if they are properly made, the industry then can depend reasonably well on the fact that it is not going back for a second round of expenditures immediately after its compliance with the first set of rules.

I know there are many different feelings about this. In one large city the air-pollution commissioner says he doesn't want anything but the common-law nuisance; that will suit everybody.

With regard to where you may go for advice on setting up rules and regulations, there is no such thing as a standard code or set of codes to fit any particular community. The rules and regulations in air pollution at this stage of the game have to be designed for your particular needs, and, of course, that makes it more difficult. If you adopt verbatim a set of rules and regulations from any particular city, you may not cover adequately the areas you want to cover, and also you may have an unusual amount of unnecessary expense.

The Air Pollution Control Association attempts to supply copies of rules and regulations to various cities. I believe the Public Health Service also offers information.

Mr. Rogers. I agree with Dr. McCabe. There is also a need for developing these programs with the cooperation of the various groups in your city or community that are involved, so that everyone understands what is expected of him. If that is done, I think you will have a successful type of program.

Dr. Merrill. As State and local health officers, we have had a lot of discussion about the problem of the use of the nuisance statutes in the field of air-pollution control. It isn't so difficult where we can point with certainty to a single source as the cause of the nuisance. But in our modern communities where we have a multiplicity of sources, you can't point to any single source, and it has been our experience that the nuisance statutes are not very practical for us, and we need to supplement them with specific legislation, tailormade to the current situation.

H. E. Furgeson. To go back to the relationship between the city planner and the air-pollution-control agencies, I think we must recognize another attack on this problem. I speak for my company—and I believe that when I speak for my company I speak for industry as a whole—and when we come into a new town and decide to build a new plant, we make a complete survey of that town. Then we make a complete survey of the plant area that we propose to build a plant on. We make a survey of population trends, which direction they will go, a survey of the meteorology and topography of the area.

This we in industry do on our own. We are very cognizant of the air-pollution rules and regulations and laws of the State in which we are planning to build this plant, as well as the local laws and municipal regulations, if there are any.

I think that this has been completely overlooked. Our company has had an air-pollution department since 1930, which is longer than many of you men have been living. We have been very active in the field. I think our city planners should be cognizant of the time, dollars, and effort that industry spends on city planning.

I would also like to direct a question to Dr. Burney or Dr. Porterfield in regard to this excellent film that they have produced. Probably only a very small group of individuals in this room realizes the many millions, literally millions of dollars, that industry spends each year, not only industry in general, but also the air-pollution-control equipment manufacturing industry, on air-pollution controls. I wonder if it would be possible for the Surgeon General to determine the total in millions of dollars that industry spends annually on air-pollution-control equipment and research, both basic and routine, and include these figures, too, in these new films.

Dr. Porterfield. I assume that would depend upon the availability of the information. Dr. Prindle, who is in the program as well as the movie, might respond.

Dr. Prindle. The Pittsburgh movie was certainly made with the wholehearted cooperation of industry. And there was mention of the industry's work in this field. And the color film which you just saw has also been made with the cooperation and assistance of industry.

Whether figures of this kind are available or not would make a good deal of difference in whether or not we can use them. We do intend, in these films, to try to convey the idea that this is everybody's problem; that it is a problem that depends on the cooperation of all concerned. And we do try to give a fair idea of the contribution of each group involved in air-pollution control.

Dr. Silverman. I am not opposed to using numbers, but I think we indicated in our summary that industry spends hundreds of millions of dollars. It is also true that the Government, in some of its own installations in the atomic energy field and through contractors and through the Chemical Warfare Service and the Ordnance Department laboratories, spends a sizable sum.

But I think it is better to state these numbers in terms of their actual interpretation, rather than just raw figures.

Mr. Williamson, of the Union Electric Co., indicated in our presentation that they spend about 2½ percent of the capital investment of a plant on air-pollution-control equipment. They wouldn't be without it today. This is true even of little industries that decide they have to take care of air pollution. There are any number of examples where air-pollution-control equipment is purchased and becomes an integral part of the process.

This, therefore, means you should speak of it either in terms of the capital cost or so much in operating cost. I think the mere statement of dollars would not necessarily carry the kind of importance that the expenditure involves.

The automobile industry, for example, spends a million dollars a year, according to the statements we had, on air-pollution research. And if you translate this into the price of their products, then you get a number that has some significance. A million dollars from the power industry may not mean very much. It wouldn't take care of a single plant.

Mr. Williamson pointed out that if the automobile industry's figures on air-pollution equipment were the same as the power industry's per kilowatt, translated into horsepower, the Ford would cost $30,000.

Dr. Barthel. This question of the amount spent by industry was explored quite fully in our session. We know that certain industries are spending a great deal, but we had a strong feeling, and a feeling of concern, that we really don't have any good overall figures. And we felt that one of our major needs is some economic research on the costs of air pollution and the costs of air-pollution controls.

Dr. Porterfield. Speaking for the Surgeon General, within the limitations that have just been mentioned, and subject, of course, to the advice of his advisory committee in this area, we would certainly have no preconceived objections to recognition of industry's contribution, in such terms as are available and would help the film.

Harry Seifert. What is the United States Department of Agriculture doing in the field of air pollution?

Dr. Brandt. The preoccupation in this field of the Department of Agriculture is by assignment to the Public Health Service. However, they do recognize that they have a very vital interest in air pollution.

The matter resolves itself into a twofold problem.

First is the one Mr. Linsky raised, supporting the technical assistance activities in general problems of land management, farm management, waste from agricultural products, and spray programs.

Perhaps more important, there is the problem of a basic research program on the actual response of plants and animals to air pollutants. I imagine this is the area in which Mr. Seifert wants information. I believe that the Department of Agriculture does have basic responsibility in this area, and that we do recognize it, and that we should have a basic research program going along on the study of this factor of environment. After all, the environment plants and animals are exposed to is of great importance. There have been recommendations made to implement such a program. I imagine that departments are not much different, and you heard Secretary Flemming's comments this morning, regarding how he could implement some of these programs.

Is anyone from the Agricultural Research Service in the audience now who may want to make a further comment on this?

Dr. Clarence M. Beatty. Supplementing what Dr. Brandt just said, we do have a very wide interest in this Department in the field of air pollution.

Any contaminant in air which affects plants, their quality, their disease resistance, or their nutrient value—or which affects animals—is of direct concern to us. And we, of course, recognize that there are such contaminants as radioactive materials. The fluoride problem has been mentioned in this conference.

We recognize that additional research is needed to establish the tolerance as well as the remedial measures, and Agriculture has considerable technical competence in this field. However, the implementation problems have been referred to by Dr. Brandt, and we know there are some limitations in that respect.

Our contribution at the present time is limited, so far as air pollution itself is concerned, to our cooperation with the Department of Health, Education, and Welfare in the form of loaning technical competence in the form of Dr. Brandt, who is assigned to the Taft Sanitary Engineering Center at Cincinnati, and his primary purpose at the present time is to appraise Agriculture's interest and obtain some idea of its potential contribution to the research field.

That is about the extent of our activities at this time.

Mr. Dutton. Ours is a professional society of mostly city planners, representing about 2,000 in this country. With respect to the position of the spokesman for Anaconda, the planners in the larger centers are trying to react to just the situation that he mentions, and to provide some differential for those industries which are well mannered, and at the same time give community protection from those industries which are not yet housebroken.

We would still, however, have to accommodate in our industrial structure some industries whose technology is not developed to the point of controlling their emissions, but whose product is still wanted for the defense effort, or for our general standard of living. And places will have to be found for those industries. It is not proposed by many planners to eliminate those industries from our national way of life.

So there is a problem of balance in planners' thinking, and the tool of zoning has a different legal structure and legal experience, I think from the general public-nuisance structure.

With respect to the comments made about more active cooperation between air-pollution-control people and planners, since our institute moved to Washington we have established telephone contact with the Department of Health, Education, and Welfare now, face-to-face contacts with a number of the people concerned. And we are responding affirmatively to the invitation of the Secretary of that Department to meet next month to discuss those areas in which there might be closer working relationships.

Ellis F. Darley. I would like a little clarification on the Department of Agriculture's participation in air pollution. We have what are called W–39 funds from the U.S. Department of Agriculture at the University of California, around $8,000 to work on research on fluorine effects on plants. Isn't this contribution a participation by the Department?

Dr. Brandt. I was remiss not to mention this contribution we are making. This is managed through the experiment station at Riverside out of funds allocated to it among other regional research funds, and this one, W–39, is a project which covers the western regional States.

O. R. Day. Speaking for the Department of Agriculture, there are several States that have a greater or smaller amount of grants on a specific basis for air pollution, usually having to do with the effect of particular pollutants on the cattle industry, on plants, or something of that sort. The funds for 1959 are in the order of $50,000 total funds, matched by the States. This is a small portion of the total Department funds which are going for some phase of air-pollution work.

Dr. Brandt. We do have a responsibility here for some basic work that is going to be applicable to all areas, and not specifically to local areas. This was one of my premises in the first part of my presentation. But we recognize that there are also local problems which can best be handled by this type of local grant.

W. W. Hodge. Are there any data available on cities where certain industries are characterized by some form of atmospheric pollution, as shown by the odor when you get near the city, as to what the effect is on people living in that city, on the average health, the birth rates, the longevity, or other factors of importance? What is the effect of living in a city where you have this odor as evidence of some form of atmospheric pollution?

Dr. Breslow. In California we have attempted such studies, although not to the satisfaction of any of us involved in them. In the whole State of California, and particularly in the metropolitan areas of Los Angeles, we have endeavored to make studies of the total mortality rate, the mortality rate of persons over the age of 65, the mortality rate of infants, and also an assessment of the morbidity rate—that is, the sickness rate—week by week and day by day, with relation to the results of air pollution that are experienced in Los Angeles. In addition, we have had under observation for several years some 4,000 persons living in nursing homes. These are, for the most part, quite feeble, elderly people of an average age group of upward of 70 years.

In all of these studies we have not yet been able to be certain of any effect on mortality or morbidity rate from the episodes of air pollution that we are experiencing. We are still quite concerned, however, about the possibility of the long-term effect of living under conditions of air pollution as they are developing in our metropolitan areas of California.

One technical difficulty of such studies is that we have in this country, and particularly in this State, a tremendous mobility of the population, so that people who live in one area of the country for the first several decades of their lives may move somewhere else to experience illness and death later on. This makes such studies quite difficult. We are, however, pursuing them to the extent of the resources that are available.

Dr. **Heimann**. The air-pollution program of the Public Health Service is currently supporting such a study, a large one, in the city of Nashville, Tenn. This is being done with the help of some technical people of the Vanderbilt University College of Medicine. Such an investigation is a very laborious epidemiological study, which is exceedingly expensive and takes many years before any reliable answers are obtained. However, we started this investigation a few months back, and we expect to continue this, and expect, furthermore, that with proper availability of funds we can extend this study to include another large metropolitan area in the East.

I can also tell you about a study which I performed back in 1950, together with the staff of the State Health Department of Maryland, in a small town in Maryland. This was an epidemiologic investigation which was based on a one-time go-round of asking questions in some 500 households in the small town, about sickness occurrence, which we then correlated with air-pollution levels that were available for that town. These were of doubtful value, but we used them anyway, as a trial. We did find, in that study, that there were no variations—there was no difference between the occurrence of most sicknesses of adults as between a dirty area, in terms of air pollution, and a clean area. The only difference was in regard to the occurrence of what is called a common cold. In an area which was dirtier, the common cold occurred with more frequency than in the area that was cleaner.

This type of investigation is exceedingly expensive and takes a long time. We hope to get some answers for you, with the help of the many agencies around the country. We should have some answers for you, I would think, within a period of 3, 4, or 5 years.

James Halitsky. As a research worker for New York University on the diffusion of contaminants in the atmosphere, I have been pretty much removed from the human aspect: that is, the interaction between contaminants and human beings. So I don't have any advanced knowledge on the subject that I would like to ask about, which is human tolerance of contaminants, and minimal levels.

I would like to know what the extent of the U.S. Public Health Service's activities could be, and the extent of the activities of various enforcement agencies, with respect to problems like these. The Department of Labor is empowered to go into an individual plant to investigate whether proper precautions are taken on different pieces of machinery to protect employees. The tenants of apartment houses call on the department of health to investigate lack of heat and hot water. Can an employee of a small industry, when he suspects that there is a dangerous level of contamination in his plant, come to an air-pollution-control agency, ask for an investigation, and see whether something could be done about clearing up this situation?

And second, would it be in order for this conference to consider the possibility of regulations requiring the installation of some kind of detection system within industrial buildings for the instantaneous, day-to-day protection of workers, and not confine its activities to research programs?

Dr. SILVERMAN. The question of monitoring within a plant with regard to problems created within the plant and the control equipment for ventilation and protection of the worker does have some relation to outdoor pollution. However, this is one of the places where jurisdictional lines seem to crop up. We might refer this question to Mr. Jack Baliff, if he is here, because he is from New York State, which has one of the best plant-examination systems for control of various industrial processes.

(The time alloted for open forum discussion expired before this interesting question could be fully answered.)

Summarization

Martin Agronsky

Commentator, National Broadcasting Co.

Washington, D.C.

This is an extraordinary conference—really extraordinary. Some really wonderful facts have come out of this meeting. I am simply fascinated, for example, for one thing, to learn that per capita production of rubbish has tripled in the past few years. The gentleman who told us about this didn't specify what kind of rubbish it was.

I would like to say to all of you that I, and all of my fellow citizens of our great republic, are deeply indebted to all of you scientists for bringing to us the glad tidings, the good news, that breathing is bad for you. I really don't know how I have ever gotten along without that happy news.

I am inclined to add that to all the other information for which we laymen are indebted to our scientists, that sweets are bad for your teeth; fat on meats provokes arterial troubles; even eating eggs can hasten hardening of the arteries; that nuclear weapons testing may bring us to the time when descendants of ours may hang by their tails, thus bringing mankind to the proper close of the evolutionary cycle, I suppose.

I am really very grateful that I am able to bring the word from this meeting to my family, my friends, and my neighbors, the very happy news that they have been worrying about their smoking producing lung cancer, but they can now stop worrying, just relax, and keep breathing, and get lung cancer without any effort at all.

Perhaps we ought to open this portion of our session right now like this: I just say to you, "Everyone all together now; take a deep breath. Fine," and ask you if you feel worse.

Seriously, this job of summarization is a bit hard for me to do. I didn't follow this meeting intensively. And I would like to thank Horace Ogden of the Public Health Service for his very healthy collating of all this material and bringing it together for me.

I would say at the beginning of the summary that the keynote of the conference, I think, was struck by Dr. Burney in his opening remarks, that is, when he spoke of the new environment that we are creating. He mentioned our explosive population growth, booming industrial production, and our headlong rush all over the country into the great metropolitan complex.

And Dr. Burney also talked about the new substances that we are introducing into our environment, the ones that apparently are making the trouble, the snythetics, high energy fuels, the products of nuclear technology.

I think your strenuous 3-day effort here, the work that you do at home, the work that brought you here, represents an attempt to solve just one of the problems produced by our brave new world—and really, to be frank about it, I suppose to solve just part of the problem.

Now, I understand perfectly well the reasons that compel you to limit the scope of this conference, but I do know, too—and I am positive you will agree with me—that any solution of the air-pollution problem which ignores radioactive wastes can be, at best, only partial.

Dr. Leake spoke briefly to that point when he referred to radiation fallout, to use his words, as "a subtle but potentially very dangerous sort of air pollution, involving all living things now."

Speaking as one living thing, as the father of four other living things, I must confess that I am deeply concerned about that particular problem.

I would like to note, too, that both the cause and the cure of nuclear pollution are exceedingly simple to define. The cause is weapons testing: and the cure is to stop the testing.

There is no need to hold a conference to figure that one out. Perhaps that is why you didn't deal with that problem. You thought it was too easy to be bothered with.

Seriously, I wish you had devoted a bit more time to it, because I feel very strongly that public awareness of that particular threat to the air we breathe is lamentably deficient.

None of this is to say that your conference has been less significant for my being partial that way. I am sure you know better than anyone else that there is plenty of work to be done on air pollution, with or without radioactivity. I suspect that what you are learning about sampling, analyzing, and controlling existing pollutants will help to prepare all of us for the challenge of the new ones as they appear—and perhaps the nuclear ones.

I have been very much impressed by the diversity of interests that are represented here. Just to glance at the registration list brings that out. And your willingness, I think, to work together for three hard days, despite this diversity, and despite the apparent conflict of some of your interests, is really most encouraging to someone like myself who is looking in on this conference from the outside.

Well, a summarizer should summarize, so let's take a look at some of the basic agreements that seem to have emerged from your sessions.

I think, first, that everyone stands agreed at this conference that air pollution is a problem, and is a problem right now; that there is no longer any time to lose; that we should be working harder, and immediately, at controlling it.

Now, at first glance that agreement may seem ridiculously obvious. If there weren't a problem, you wouldn't be here.

But all of us know this, too, and I think it is worth remembering, that some experts tried to pretend—and not very many years ago—that the problem wasn't there at all. You may argue as to what kind of problem it is, but I do think it is an important thing to note at the beginning of the summarization that you agree that there is a problem and that there is work to be done, and to be done quickly.

The second point that I would make is that everyone seems to agree that it promises to get worse.

Now, these projections of industrial and population growth can't be denied, even though in those areas such as the elimination of smoke and grit in which progress has been made, I think this conference amply demonstrates we are still barely holding our own—not really getting very far ahead.

I was interested to know that the quantity of soft coal—interesting statistics came out of this meeting—used to produce electric power in this country has doubled in the last 10 years. I know I was one who was inclined to feel that the substitutes for coal had cut down tremendously on coal production, but it isn't that way. Coal is one product that provides so many of the irritants if you put it in the atmosphere.

I think Dr. Dixon stated a future prospect in that area very picturesquely. He said that if gas masks are not to become as common in a hundred years as shoes are today, we should do well to heed our submerged instincts of self-preservation and remember that, whatever other uses man may devise for it, air is still essentially for breathing.

Now, all your discussion groups mention and delineate the responsibilities for everyone concerned.

Everyone here apparently agrees that Public Law 159 should be extended beyond 1960.

Several groups have urged, too, that there should be no ceiling placed on appropriations.

As far as I can tell from the deliberations, there seems to be tacit agreement, too, that the Federal role outlined by the Air Pollution Act is about what it should be, that is, research, technical assistance, and training.

And again, as far as I can make out from your deliberations, from what was said on the floor and in committees here, if anyone does feel that the Federal Government should move into the enforcement field at this time, it doesn't appear in your reports.

Now, that is one area where again as a layman and admittedly no expert, I am inclined to feel that this conference should have gone a little bit further. I do feel that there is a Federal responsibility here. For example, States are unable to do these things; cities are unable to do them. Everybody passes the buck. Certainly, there should be some authority to which the people can turn to get some action in this area.

There ought, perhaps, to be some Federal involvement, perhaps in the area of legislation, perhaps in the area of enforcement. One area that occurs to me where perhaps something constructive might be done is taxation.

For example, in Pittsburgh, where some extraordinarily effective work has been done in cutting down air pollution by local industries, I am told that they were only able to do this at the cost of literally tens of millions of dollars. Well, the management was sufficiently enlightened to undertake it. Perhaps there were city pressures, and it was generally a city program that brought it all about. But nevertheless I do think that industries elsewhere, perhaps not so self-enlightened, might be induced to go along further than they do now if something were done in the area of taxation which would enable them to write off some of the money that they spend on cleaning up air pollution, cutting down pollution in their manufacturing processes.

That is an area in which this conference perhaps didn't go as far as it might have gone.

Another point that I think should be made by a summarizer is that apparently it is the consensus of this conference that there should be strong support for tackling air pollution by problem areas, breaking it down, in the words of group "F." That is their conclusion, that that be done so that if five cities or five counties or several States share the same messy atmosphere, they can all get together and work together to clean it up.

And again, just looking at this as a layman, not as an expert, and from the outside, that does seem to make extraordinarily good sense to me.

Group "C" assigned some specific jobs to the doctors and the medical societies. They suggested—rather politely, I thought—that the doctors might ask themselves whether their organizations were giving enough attention to the prevention of diseases related to air pollution.

Again as a layman, I am inclined to broaden that to all kinds of disease, preventive medicine in general.

And as to who is responsible for cleaning up, as far as I can make out, everyone in this conference agrees that the polluter, either the industry or the individual, should pay what it costs to apply the necessary controls.

I suggested earlier that there could be something of an amelioration of that particular individual responsibility or company responsibility.

I thought that on the floor here just a few moments ago Dr. Dorothy Muncy made an interesting and useful suggestion in which she proposed that there be active cooperation between the city planners and air-pollution experts in open areas toward which cities are moving these days.

Without exception, the discussion groups also seemed to recommend more education for the public. Well, that's a standard recommendation of every conference. It is almost predictable in advance. But I would like to say, in the words of the old song, "Everybody talkin' about heaven ain't goin' there."

The public doesn't become educated by magic or by fiat. It does not become educated if every time some extra money appears in your budget what you do is hire another technician instead of an interpreter. An interpreter has a place. Perhaps it is underestimated.

Likewise, every discussion group at this meeting seems to have suggested specific areas for research. Several lists of specific projects were proposed, all of them undoubtedly necessary, and undoubtedly urgent. But no timetable or priority listing seemed to have emerged from the conference.

I suppose that was inevitable. Conference recommendations tend to be vague as possible, generally. But I wonder why no priority. Certainly, some things are more important than others.

These are primarily the points of agreement that I would set forth as the summarizer.

Let's look now at the points of disagreement.

A measure of the successful conference is not the number of recommendations upon which everyone agrees, but the number of genuine conflicts that are aired. I agree that nothing could be duller than a conference at which everybody sits around nodding his head in agreement.

Well, I gather that this was not a nodding conference. To that extent I suspect it was a successful one.

But Disagreement No. 1 seems to be the health issue.

We don't get any clear-cut feeling, really, watching these deliberations from the outside, that everybody is agreed on the degree of menace that is presented to our health by air pollution. That is, is air pollution killing us by inches, or is it no more than just a nuisance?

Is breathing really bad for us? How bad is it?

I am inclined to feel that as a reporter now, I am entitled to have an opinion. I would find it difficult, writing a piece about this conference, to write anything with certainty in my lead about exactly what is bad for us in the air that we breathe, and how bad it is.

There is no degree of specificity there. You have to define more clearly what the problem is, and how much of a problem it is.

Dr. Mancuso and Dr. Kotin presented some strong evidence, too, on the association between air pollution and lung cancer. Well, as a reporter, I can tell you, that is the big news story, inevitably. Dr. Mancuso's statistics on the patterns of distribution of lung cancer, I think would certainly indicate to someone like me that there is something in the city air which does something to us. It would indicate to me that I am quite right not to like it.

Dr. Kotin's work with animals may not be directly applicable to people. I am very much taken by his off-the-cuff remark that extrapolation varies according to the evangelism of the investigator.

A friend of mine, a doctor who is a cancer expert, was highly amused because I came to him very alarmed when the first stories came out about the relation between smoking and lung cancer. I said to him, "What does this all mean? I'm glad to see you're still smoking."

And he said to me that, well, as far as he was concerned, the only thing they had been able to prove so far was that mice shouldn't smoke.

I would like to add that I am breathing as much city air as the next man. All of us feel that way about it.

Now, opponents of the health notion seem to claim, too, in this conference that this is purely circumstantial evidence. I noticed that Dr. Burney, for one, nailed that point. Dr. Burney nailed that in his opening speech, when he drew the analogy to the control of epidemics years ago, when foresighted leaders noticed the association between disease and filth and cleaned up the filth and thereby improved health greatly. Then, Dr. Burney said, years later they found out why.

Well, if we must err, I am inclined to go along with Dr. Burney. I am willing to err on the side of excessive concern.

Also, although the evidence on health effects may be thin, I certainly haven't noticed any evidence produced around here that air pollution is good for you. Certainly, all the evidence there is indicates or suggests or implies, or whatever mild word you want to use—whatever scientific word you want to use, if you want to be extremely accurate—all of it indicates that air pollution is bad for you in some degree or other. Goodness knows, that is reason enough to do something about it, and reason enough to hold a conference about it.

One group, too, I see, mentioned the danger of public hysteria if there were too much emphasis placed on the health effects of air pollution.

Personally, I seriously question the likelihood of such hysteria. Goodness knows, there has been enough stress lately on the adverse effects of cigarette smoking. I haven't noticed any hysterical abandoning of that activity. We are still smoking several million more packs every year. We still don't have any legislation against cigarettes of the type this group is worried about.

The concern of some was expressed here, I understand, that if the public got too exicted, there might be pressures that would be brought on legislators that would result in extreme and even extremely crippling legislation against industry.

Well, this is not a valid concern, in my opinion. I think any reporter who has worked around here long enough—certainly, it has been my experience around here—knows that it is not industry but the public that needs to watch itself in the clinches!

Disagreement No. 2 that showed up here was that there was a great debate on automobile exhaust. The automobile manufacturers seem willing to agree that that is a genuine problem in Los Angeles, but not anywhere else. They say they are spending a million dollars a year on research in this field. They imply that that is a considerable investment, a million dollars a year.

Well, with all due respect to a $20 billion industry, I am not impressed.

Nor am I convinced that Los Angeles has a monopoly on the problem. As someone in one of the discussion groups remarked, too, exhausts speak for themselves every time you drive to work. I think this makes sense. I'm with him.

Group "E" recommended that the automobile industry should continue research at a vigorous rate. There again, as I have noticed in a lot of these proceedings, is the same lack. No one has attempted to specify what they mean by vigor, what degree of vigor is necessary. Some one ought to do that.

Some concern was expressed, too, about the effects of fuels, and some possibility of changing the chemical makeup of fuels, of petroleum, for example, in some way. The automobile industry is inclined to stand aside—you know, "You first, Alphonse"—and say it is up to the oil industry to do something about it. The oil industry, I understand, is quite willing to say to the automobile industry, "Why that's all right, fellows, we'll let you have the responsibility and you do something about it."

The fact is, both of them ought to do something about it. The Federal Government ought to see that they do something about it, if something can be done about it. And yet no recommendation to that effect emerged from the conference.

I don't know what it is with you fellows. You almost sound like you are taking the approach to some of these industrial problems that some of us in my business get familiar with, the Madison Avenue approach.

Now, there appears to be a general disagreement, too, between those who recommend doing something now and those who recommend doing nothing until we know everything. I covered that to some extent. I said "appears" because it doesn't seem that this is really a disagreement. It is an irrelevant matter, a matter of emphasis.

Obviously, there are tremendous gaps in our knowledge about what is in the air, where it comes from, and what to do about it. But these gaps do not justify a "do-nothing-until-you-hear-from-me" attitude.

We already know a lot. We apparently suspect more. Many things that we do know are not being applied. The conference ought to emphasize that.

Research and action must go together. There is no conflict between the two.

Perhaps it would have been desirable if the conference had specified priorities and timetables in this area also.

Secretary Flemming this morning called for national goals with time limits and dollar signs attached. I agree that both of those are necessary, both as signposts for future action and as yardsticks to measure progress. Your words this week might well furnish a basis on which you can build that kind of master plan.

Well, I have been a bit harsh on you, I guess, in some areas. I think, however, overall you get the impression that this has been a successful conference. At least two of the discussion groups recommended you have more of them, perhaps at more regular intervals. You can decide best about that recommendation.

Certainly, what you do now after you go home forms the real evaluation of the meeting. A year from now we may really begin to know whether this National Conference on Air Pollution was a boon or a "boondoggle." You have got your work cut out for you. More people than ever before are going to be looking over your shoulder while you do it—which I think is a pretty good thing, too.

The conference itself, whether you intended it or not—and I imagine you did—has generated a lot of public interest in this subject. And I am sure the worsening of the air has generated a good deal more. Certainly, all of you, no matter which side of which fence you are on, are going to have to get used to one fact: the public won't rub its eyes or hold its nose forever, much less clutch its chest, without insisting that something be done.

We have put up in this country with a lot of things for a great many years, but sooner or later we will rise up and yell.

I think we have raised our sights, too, since the early days of the industrial revolution, to at least learn to ask some embarrassing questions. And when we get scared enough, or mad enough, or just plain tired enough, of something that has bothered us—I speak now as a member of the public—we become very obnoxious until that something is removed.

I would like to close on the note that there is a strong tide in this country for better health and a cleaner and more comfortable environment. Again, you can't stem it if you want to.

Again as a reporter and outsider and observer, and also as a citizen, not an expert, I would like to conclude by telling all of you that the people will no longer accept push-button living in a stinking city, and they will see that pollution is controlled. And you can help them.

Concluding Remarks

Dr. John D. Porterfield
Deputy Surgeon General
Public Health Service

Mr. Agronsky has done us a great service. Whether or not we agree wholeheartedly with his summarization of the results of this conference, we have here the reaction of an alert and perceptive member of the public and we will review this carefully over the months ahead.

To my mind, the 3 days of this conference are only a "breather," a time for taking stock, a summarization, one of the early chapters in the book, and we can anticipate, not that our work is done with the adjournment of this conference, but that we now have the advantage of greater visibility, perhaps, to go forward from where are, both in research and in control activities.

In conclusion, I think we can look forward to considerable reaction to this conference and, I hope, to considerable assistance in our endeavors because of it.

With that, we are adjourned.

ADJOURNMENT

APPENDIX

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